Nutrient and Dissolved Oxygen TMDLs for Pheasant Lake in Dickey County, North Dakota

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1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

Pheasant Lake is a small reservoir on the Elm River and is located in Dickey County approximately six miles west of Ellendale, North Dakota. In cooperation with the North Dakota State Water Commission, North Dakota Game and Fish, and Dickey County Water Resource Board; Pheasant Lake was completed in 1963. Pheasant Lake was constructed for the purpose of water recreation and includes a boat ramp, parking lot, swimming beach, and picnic area.

The Pheasant Lake watershed is a 60,940 acre watershed located in Dickey County in southeast North Dakota (Figure 2). The watershed of Dickey County lies completely within the Northern Glaciated Plains Ecoregion (46); which is characterized by a flat to gently rolling landscape composed of glacial till. The subhumid conditions foster a grassland transition between the tall and shortgrass prairie. Though the till soil is very fertile, agricultural success is subject to annual climatic fluctuations. Table 1 summarizes some of the geographical, hydrological, and physical characteristics of Pheasant Lake and its watershed.

Table 1. General Characteristics of Pheasant Lake and its Watershed.

Legal Name	Pheasant Lake
Major Drainage Basin	James River Basin
Nearest Municipality	Ellendale, North Dakota
Assessment Unit ID	ND-10160004-005-L_00
County Location	Dickey County, North Dakota
Physiographic Region	Northern Glaciated Plains
Latitude	46.82664
Longitude	-100.63093
Surface Area	165.8 acres
Watershed Area	60,940 acres as indicated by the AgNPS Model
Average Depth	7.3 feet *North Dakota Game and Fish bank full/spillway elevation*
Maximum Depth	19.8 feet
Volume	1,212.2 acre-feet
Tributaries	Elm River and three small unnamed tributaries
Type of Waterbody	Constructed Reservoir
Dam Type	Constructed Earthen Dam
Fishery Type	Black Bullhead, Black Crappie, Bluegill, Yellow Perch, Walleye, Northern Pike

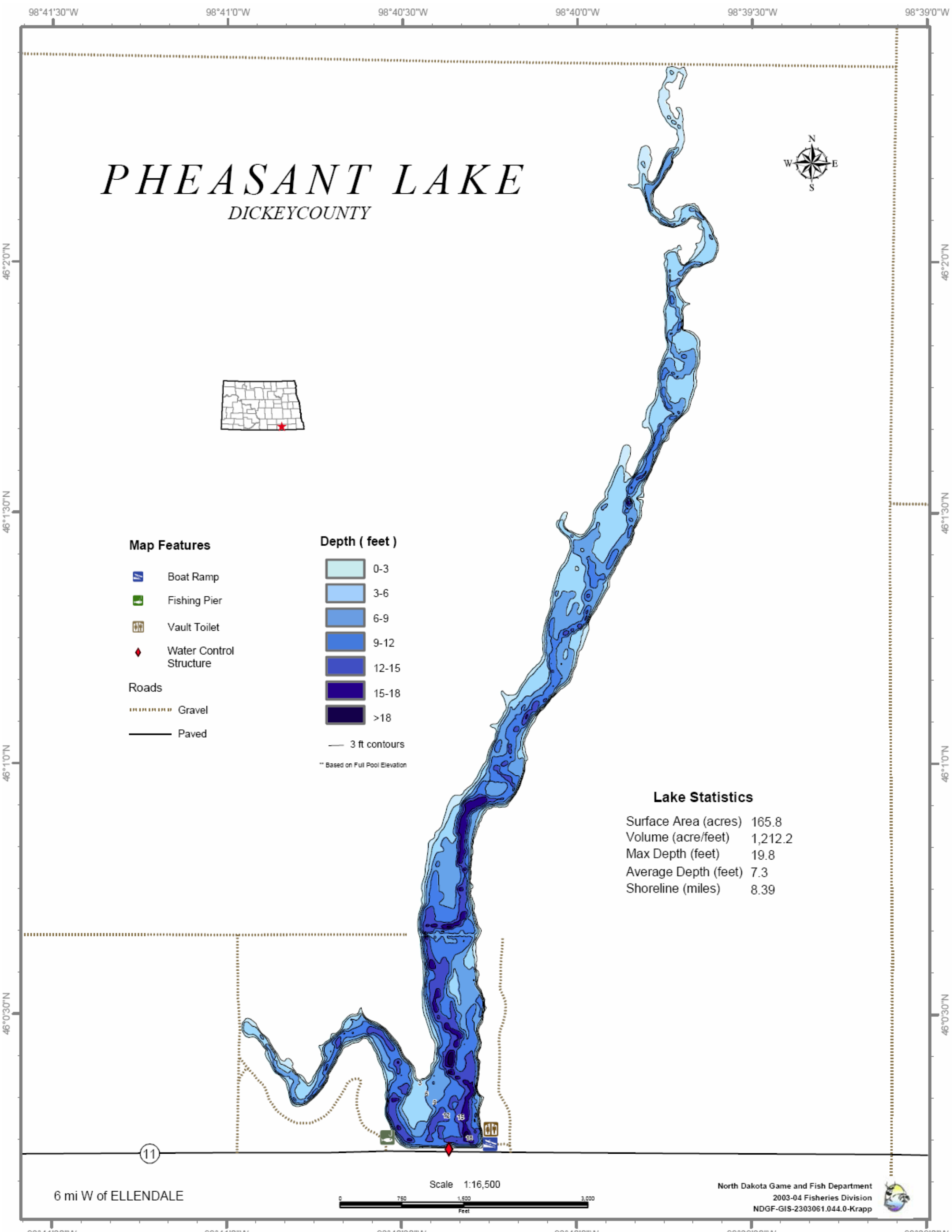


Figure 1. North Dakota Game and Fish Contour Map of Pheasant Lake.

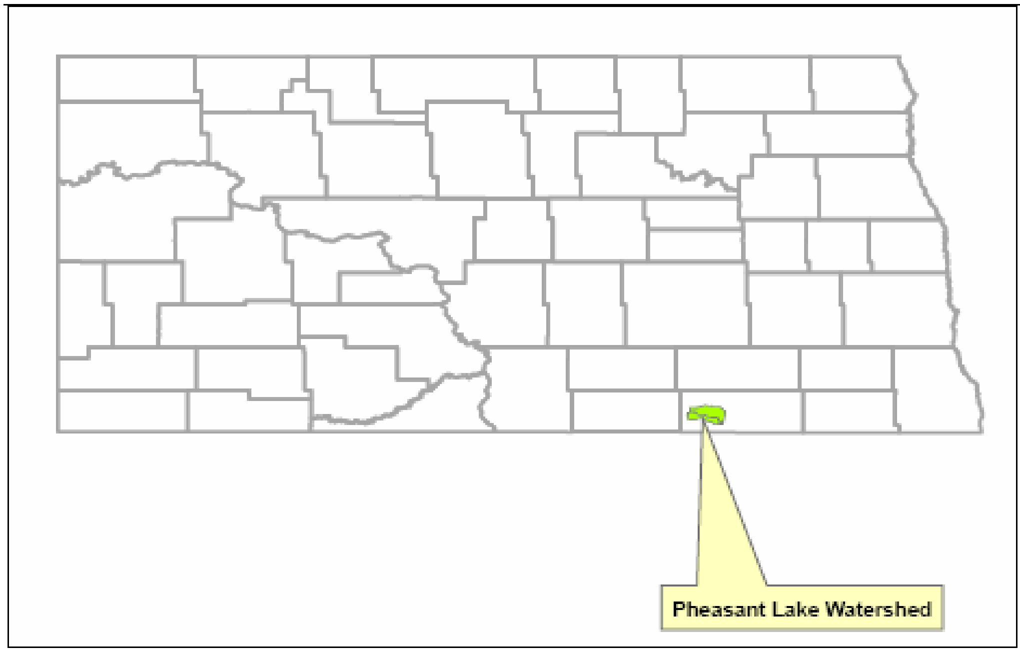


Figure 2. General Location of the Pheasant Lake Watershed.

1.1 Clean Water Act Section 303(d) Listing Information

As part of the Clean Water Act section 303(d) listing process, the North Dakota Department of Health has identified Pheasant Lake as an impaired waterbody (Table 2). Based on a Trophic State Index (TSI) score, aquatic life and recreation uses of Pheasant Lake are impaired. Aquatic life is listed as impaired due to nutrients, sedimentation, and low dissolved oxygen. Recreational use is impaired due to nutrients. North Dakota's section 303(d) list did not provide any potential sources of these impairments. Pheasant Lake has been classified as a Class 3 warm-water fishery, "capable of supporting growth and propagation of nonsalmonid fishes and associated aquatic biota" (NDSDHCL, 1991).

The fishery that was initially established within the reservoir in 1964 consisted of rainbow trout. Subsequent stockings included northern pike, walleye, yellow perch, crappie, bluegill, largemouth bass and smallmouth bass. In 1991, test netting results showed the fish community was dominated by black bullheads and periodic winter kills. These repeated die offs were caused by an eutrophic condition and subsequent anoxia below the thermocline.

Table 2. Pheasant Lake Section 303(d) Listing Information (NDDH, 2004).

Assessment Unit ID	ND-10160004-005-L_00
Waterbody Name	Pheasant Lake
Class	3 - Warm-water fishery
Impaired Uses	Fish and Other Aquatic Biota (Fully Supporting but Threatened), Recreation (Fully Supporting but Threatened)
Causes	Nutrients, Dissolved Oxygen, Sedimentation
Priority	High
First Appeared on 303(d) list	1998

1.2 Topography

The topography of the Pheasant Lake watershed varies substantially from east to west. The eastern quarter lies within the Missouri Coteau physiographic region, an erosion remnant of the late Wisconsin Age. The Missouri Coteau extends in a north-south direction and is characterized by rolling hills and valleys with slopes ranging from 3 to 20 percent. Soils in this region are deep and well drained from medium-textured to moderately fine glacial till. The remaining three quarters which include the Pheasant Lake watershed lie within the Glaciated Plains physiographic region. This is a region that is less hilly and more fertile with slopes ranging from 0 to 6 percent. (NDDoH, 1992).

The elevation in Dickey County ranges from 2,240 feet MSL in the southwest to approximately 1,286 feet MSL in the southeast. As a result of glaciation Dickey County has numerous deposits of sandy and gravelly material usually overlying large aquifers.

1.3 Land Use/Land Cover

Land use in the Pheasant Lake watershed is primarily agricultural (88%). Approximately 42% of the land is cropland with the other 58% in low density urban development, haylands, pasture, water, or in the conservation reserve program (CRP). The majority of the crops grown consist of spring wheat, millet, grass-legume hay, flax, corn and sunflowers. Livestock are raised primarily in the western quarter of the county in the more sloping areas. Figure 3 and Table 3 shows the distribution of land uses in the Pheasant Lake watershed.

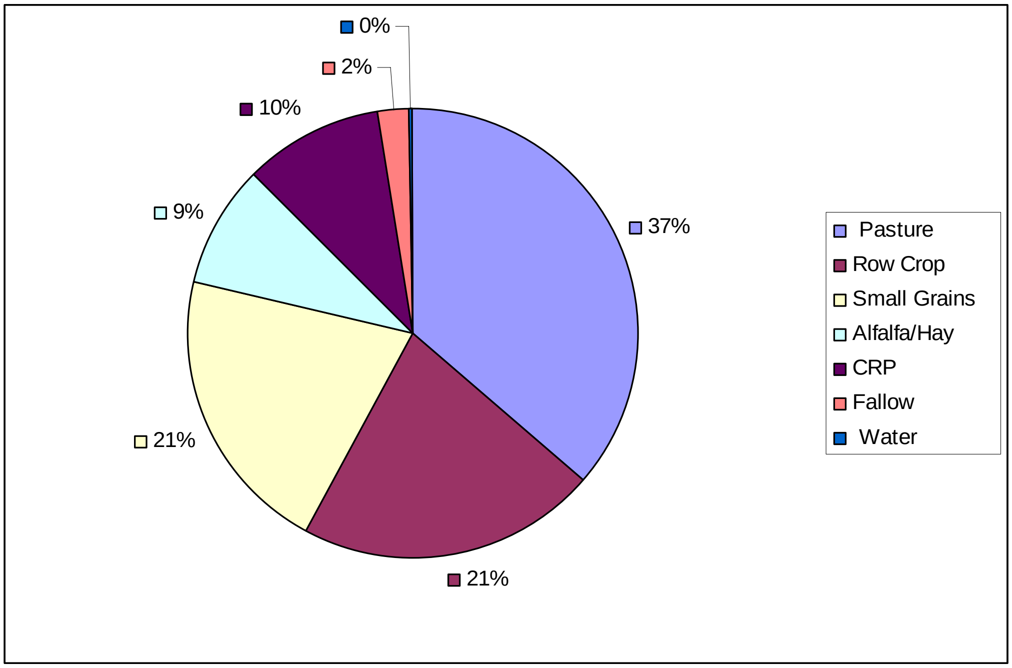


Figure 3. Pheasant Lake Watershed Landuse Data.

Table 3. Agricultural and Low Density Urban Development Data.

Subwatershed	Farmstead	Animal Feeding Operations	Lake Cabins
Immediate Watershed	4	0	70
Elm River	10	6	0
Northwest	4	4	0
West Northwest	7	5	0
West	1	0	0
Totals	26	15	70

1.4 Climate and Precipitation

Dickey County has a subhumid climate characterized by warm summers with frequent hot weather and occasional cool days. Winters are very cold influenced by arctic air surging over the area. Average temperatures range from 14º F in winter to 69º F in summer. Precipitation occurs primarily during the warm period and is normally heavy in later spring and early summer. Total annual precipitation is about 20 inches. About 16 inches or 80 percent of rain falls between April and September. Average seasonal snowfall is approximately 32 inches. Winds prevail generally from the south to southwest at an annual average wind speed of 14 mph. Figure 4 shows the annual precipitation for Dickey County from 1991-2005.

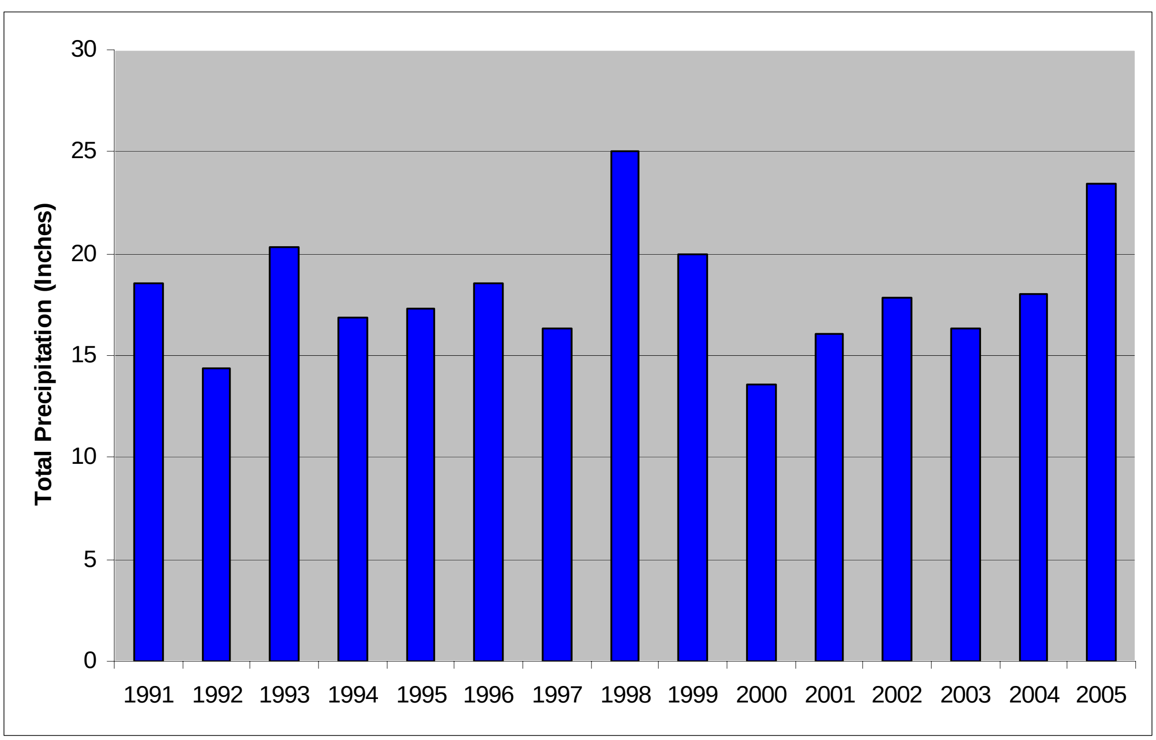


Figure 4. Total Annual Precipitation at Oakes, North Dakota from 1991-2005. North Dakota Agricultural Weather Network (NDAWN).

1.5 Available Water Quality Data

1.5.1 1991-1992 Lake Water Quality Assessment Project

A Lake Water Quality Assessment Project (LWQA) was conducted on Pheasant Lake in 1991-1992. Two samples were collected in the summer of 1991 and once during the winter of 1992. Samples were collected at one site located in the deepest area of the lake (381125). During summer sampling in July and August of 1991 Pheasant Lake was not thermally stratified. Dissolved oxygen concentration during this time period was adequate to maintain aquatic life except near the bottom where concentrations were less than 5 mg L^{-1}. Winter sampling in January of 1992 showed dissolved oxygen concentrations above 5.0 mg/L^{-1} at all depths.

The 1991-1992 LWQA Project characterized Pheasant Lake as having a volume weighted mean concentration of total phosphate as phosphorus of 0.667 mg L^{-1}, which exceeded the State's target concentration of 0.1 mg L^{-1} during all sampling occasions. Nitrate + Nitrite as nitrogen exhibited a volume weighted mean concentration was 0.205 mg L^{-1}. According to State standards, this is below the target concentration of 1.0 mg L^{-1}. Other sample parameters and average volume weighted mean concentrations are provided in Table 4. A volume-weighted mean was calculated using a stratified sampling technique to describe the general chemical characteristics of the reservoir. The volume-weighted mean was calculated by weighting the parameter analyzed by the percentage of water volume represented at each depth interval. The ratio of total phosphate as phosphorus to nitrate + nitrite as nitrogen is 3:1. This indicates that Pheasant Lake is nitrogen limited, caused by an over abundance of phosphorus. These conditions favor nitrogen fixing algae like some blue-green algae.

Trophic status was also determined using the water quality data collected during the LWQA project. Pheasant Lake was identified as being hypereutrophic, this was determined based on summer total phosphate as phosphorus concentrations, secchi disk transparency. Total phosphate concentrations averaged 0.766 mg L^{-1} and secchi disk transparency averaged 0.6 meters.

Table 4. Data Summary for the Pheasant Lake Lake Water Quality Assessment (1991-1992).

Parameter	Units	Lake Water Quality Assessment (1991-1992)				Volume Weighted Mean
		Max	Median	Avg	Min	
Total Phosphorus	mg/L	0.802	0.762	0.674	0.432	0.667
Dissolved Phosphorus	mg/L	0.783	0.734	0.624	0.351	0.617
Total Nitrogen	mg/L	0.297	0.175	0.179	0.067	0.172
Total Kjeldahl Nitrogen	mg/L	1.87	1.51	1.51	1.28	1.52
Nitrate/Nitrite	mg/L	0.325	0.260	0.203	0.027	0.205

1.5.2 2001-2002 Pheasant Lake TMDL Project

The James River Soil Conservation District (SCD) conducted a water quality assessment of Pheasant Lake and its watershed from March 2001 to February 2002. Sampling was done on four inlet sites (385080, 385081, 385082, and 385083), one outlet site (380017), and three reservoir sites (381125, 381127, and 385094) on Pheasant Lake and accompanying watershed. Sites are identified in Table 5 and Figures 5 and 6.

Stream Sampling

For logistical and statistical reasons, the Pheasant Lake watershed was stratified into five subwatersheds (Figure 5). In each of these five subwatersheds, one stream sampling site was established and sampled throughout the open water season. Sampling frequency for the stream sampling sites was stratified to coincide with the typical hydrograph for the region. This sampling design resulted in more frequent sampling during spring and early summer, typically when stream discharge is greatest and less frequent sampling during the summer and fall. Sampling was discontinued during the winter ice cover. Sampling was also terminated if the stream stopped flowing. If the stream began flowing again, water quality sampling was reinitiated.

Lake Monitoring

Water quality data was collected from Pheasant Lake at three sites representing the inlet (381127), mid-lake (385094), and deepest (381225) areas of the reservoir. (Figure 6) Samples were collected eight times during the open-water period and once under ice cover conditions.

The inlet and central sites of the lake were sampled at a depth of ½ meter, and the deepest site was sampled at three discrete depths. The three depths were at ½ meter, mid-depth, and ½ meter off the bottom unless thermal stratification was identified. If thermal stratification was occurring, then the depths were modified to ½ meter below the surface, the center of the metalimnion and ½ meter off the bottom. Chlorophyll-a was collected only over the deepest area only using a 6-foot depth integrated sampler. Sampling and analysis variables are shown in Table 6.

Table 5. General Information for Water Sampling Sites for Pheasant Lake.

Sample Site	Site ID	Dates Sampled		Latitude	Longitude
		Start	End		
Stream Sites					
Elm River	385083	3/21/01	7/2/01	46.05565	-98.65853
Northwest Tributary	385082	3/21/01	7/2/01	46.05546	-98.67933
West. NW. Tributary	385081	3/21/01	7/2/01	46.01886	-98.6932
West Tributary	385080	3/21/01	7/2/01	46.0054	-98.69323
Pheasant Lake Outlet	380017	3/21/01	7/2/01	46.00358	-98.67246
Lake Sites					
Inlet Site	381127	6/4/01	2/7/02	46.03922	-98.6622
Mid-Lake Site	385094	6/4/01	2/7/02	46.020446	-98.66765
Pheasant Lake Deepest	381125	6/4/01	2/7/02	48.87833	-98.67451

The James River SCD followed the methodology for water quality sampling found in the QAPP Quality Assurance Project Plan for the Pheasant Lake TMDL Project. (NDDoH, 2001)

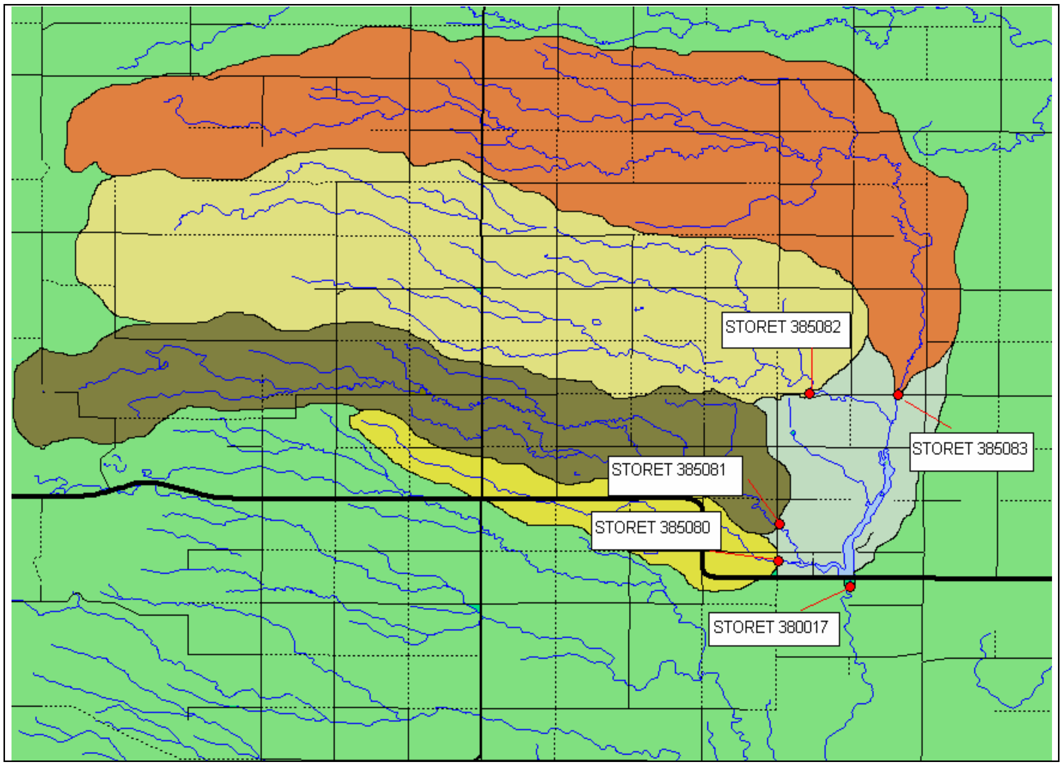


Figure 5. Stream Sampling Sites for Pheasant Lake.

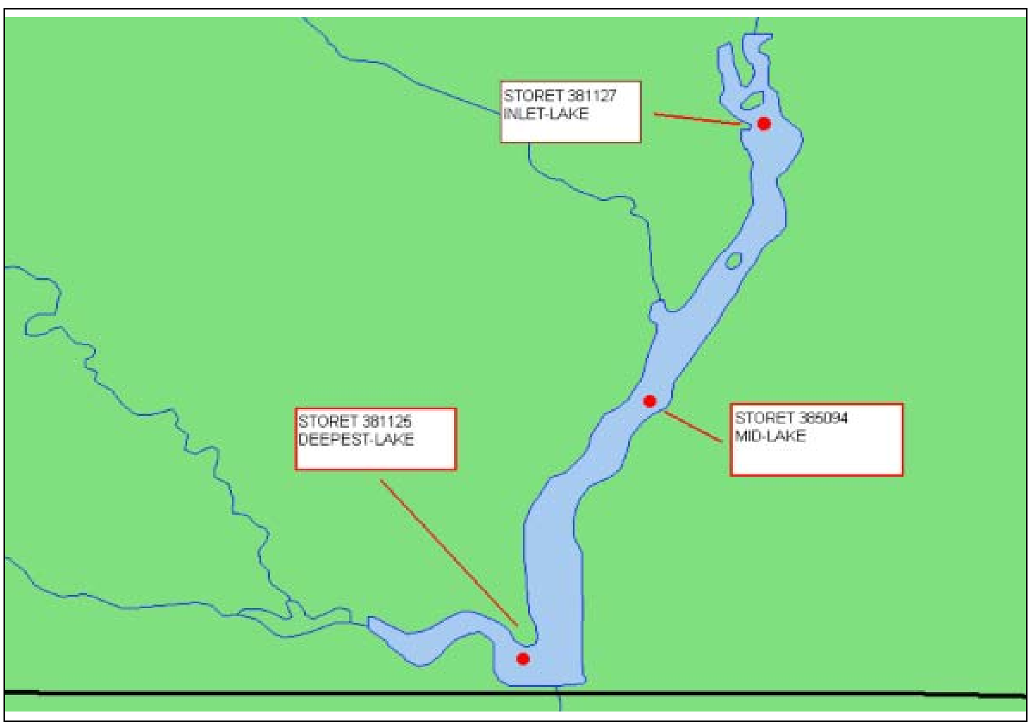


Figure 6. Lake Sampling Sites for Pheasant Lake.

Table 6. Pheasant Lake Sampling and Analysis Parameters.

Field Measurements	General Chemical Variables	Nutrient Variables	Biological Variables
Secchi Disk Transparency	pH	Total Phosphorus	Chlorophyll-a
Temperature	Specific Conductance	Dissolved Phosphorus	Phytoplankton
Dissolved Oxygen	Major Anions & Cations	Total Nitrogen	
	Total Suspended Solids	Total Kjeldahl Nitrogen	
		Nitrate plus Nitrite Nitrogen	
		Ammonia Nitrogen	

1.5.3 Nutrient Data

Surface water quality parameters were monitored in Pheasant Lake at three sites between June 2001 and February 2002. A data summary table for these three sites is summarized in Table 7. The data shows average total phosphorus and dissolved phosphorus concentration values for the three sites ranging from 0.506-0.544 mg L^{-1} and 0.442-0.490 mg L^{-1} respectively. Total Kjeldahl nitrogen and nitrate/nitrite values ranged from 1.46-1.50 mg L^{-1} and 0.011-0.017 mg L^{-1}. Total nitrogen had a 1.48-1.52 mg L^{-1} value range.

When comparing ratios of all nutrient samples collected at Pheasant Lake's deepest site, samples showed a nitrogen shortage, strongly indicating that the lake is nitrogen limited. Total nitrogen to total phosphorus ratios ranged from a low of 2.4:1 to a high of 3.6:1, with the majority being below 3:1. Ratios of inorganic nitrogen to dissolved phosphorus ranged from 0.01:1 to 0.12:1, with the majority being near or below 0.1:1. It is important to note that a shortage of nitrogen is rarely limiting in a lake system. Instead, this condition favors less desirable species of algae that are able to affix free nitrogen and dominate the entire photic zone.

Table 7. Data Summary for Pheasant Lake TMDL Project 2001-2002.

Parameter	Inlet Lake Site (381127)					Mid-Lake Site (385094)					Deepest Lake Site (381125)				
	N	Max	Median	Avg	Min	N	Max	Median	Avg	Min	N	Max	Median	Avg	Min
Total Phosphorus (mg/L)	10	0.629	0.483	0.506	0.396	10	0.646	0.479	0.508	0.386	10	0.727	0.561	0.544	0.413
Dissolved Phosphorus (mg/L)	8	0.523	0.436	0.442	0.357	8	0.542	0.434	0.442	0.349	8	0.619	0.514	0.490	0.379
Total Nitrogen (mg/L)	10	1.77	1.53	1.52	1.27	10	1.75	1.53	1.50	1.27	10	1.86	1.48	1.48	1.26
Total Kjeldahl Nitrogen (mg/L)	10	1.75	1.51	1.50	1.25	10	1.73	1.51	1.48	1.25	10	1.84	1.46	1.46	1.24
Nitrate/Nitrite (mg/L)	10	0.06	0.01	0.014	0	10	0.08	0.01	0.017	0	10	0.02	0.01	0.011	0.01
Chlorophyll-a (μg/L)	0	0	0	0	0	0	0	0	0	0	6	30	12.5	11.83	0.5
Secchi Disk (meters)	5	2.7	1.1	1.34	0.3	7	2.7	1.1	1.27	0.3	7	1.7	1	1.07	0.6

Nutrient concentrations from Pheasant Lake in 2001-2002 can be compared to data collected from the 1991-1992 Lake Water Quality Assessment. Nutrient concentrations reported for the 2001-2002 TMDL Project were higher for total phosphorus, dissolved phosphorus, and total nitrogen but lower for nitrate/nitrite. Total Kjeldahl nitrogen appeared to be unchanged when compared to 1991-1992 LWQA data (Tables 4 and 7).

1.5.4 Dissolved Oxygen and Temperature

At no time during the open water period of 2001 or ice cover of 2001-2002 did Pheasant Lake develop strong thermal stratification. Profiles collected at the three in-lake monitoring sites indicate the inlet and deepest areas do not thermally stratify, and the middle area experiences periodic weak thermal stratification during the hottest times of the summer (Figures 7, 9, and 11).

Dissolved oxygen concentrations dropped below the State's minimum standard concentration of 5.0 mg L^{-1} at varying depths throughout the year. The hot summer months appear to be the most critical time period for maintaining dissolved oxygen concentrations. Concentrations dropped below the State standard of 5.0 mg L^{-1} at a depth of approximately 7 feet at the inlet site, and 9 feet at the mid-lake site on the sampling dates of July 25, August 2 and August 29 (Figure 8,10, and 12).

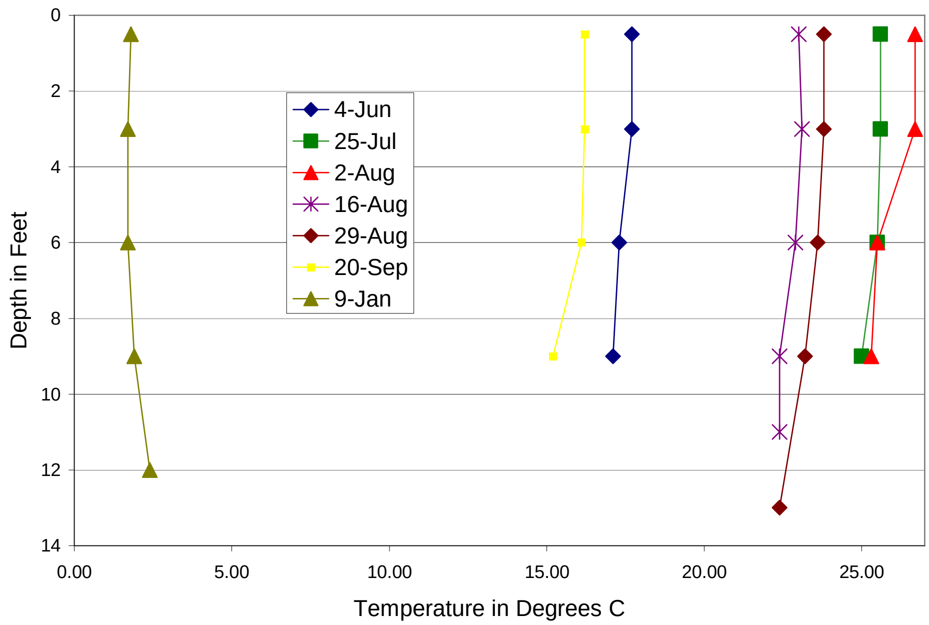


Figure 7. Summary of Temperature Data for the Pheasant Lake Inlet Site (381127).

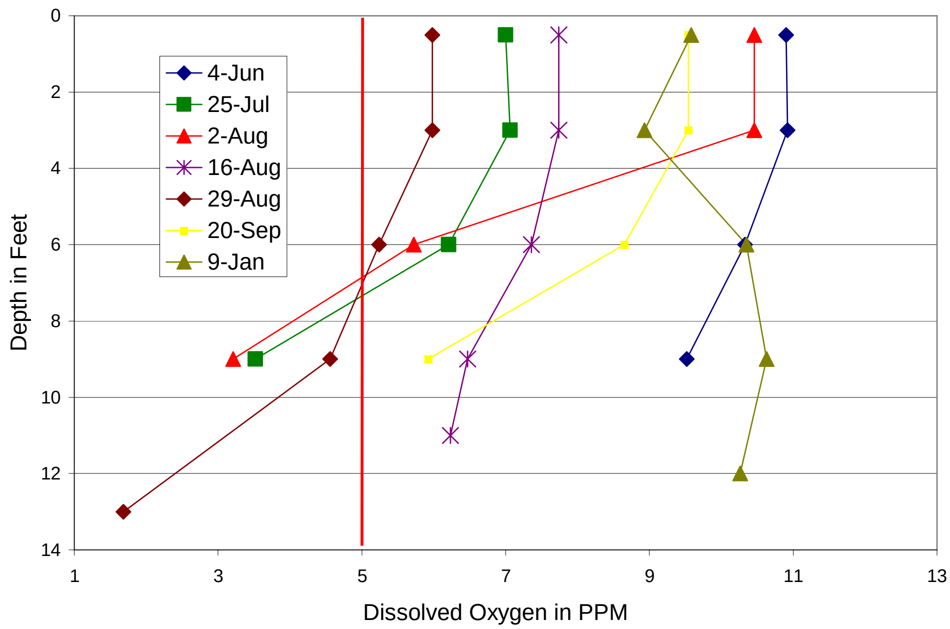


Figure 8. Summary of Dissolved Oxygen Concentrations for the Pheasant Lake Inlet Site (381127).

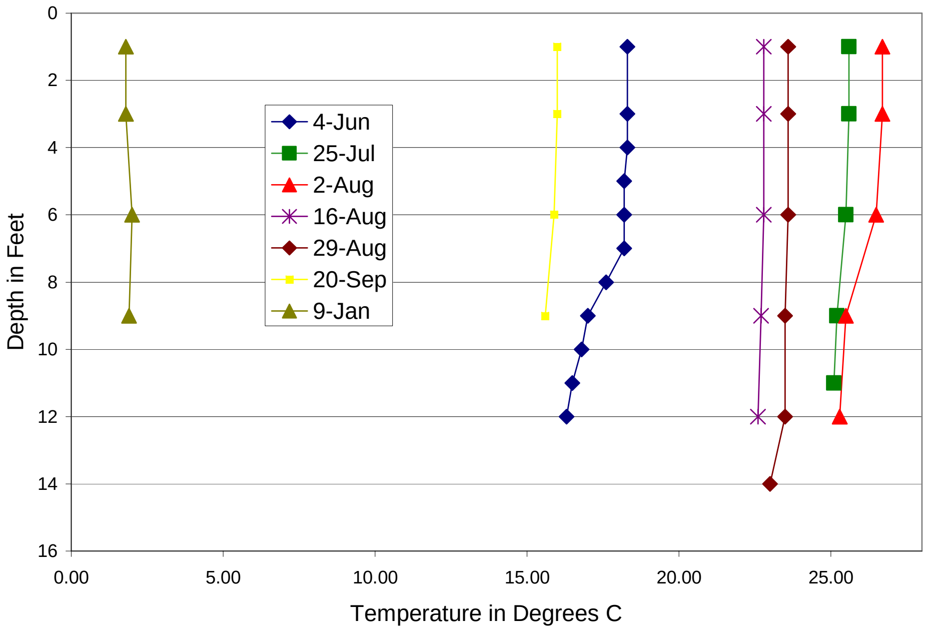


Figure 9. Summary of Temperature Data for the Pheasant Lake Mid-Lake Site (385094).

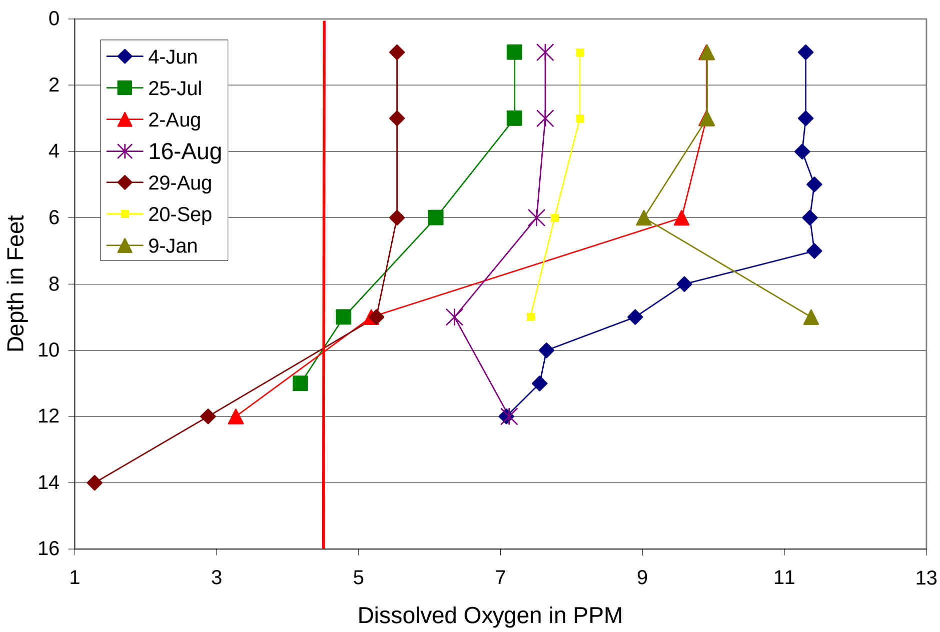


Figure 10. Summary of Dissolved Oxygen Concentrations for the Pheasant Lake Mid-Lake Site (385094).

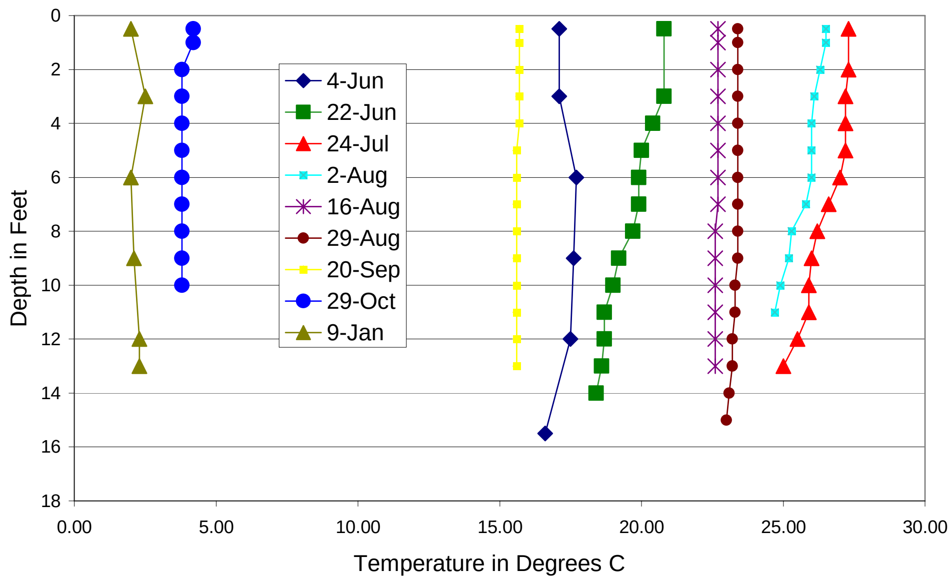


Figure 11. Summary of Temperature Data for the Pheasant Lake Deepest Area Site (381125).

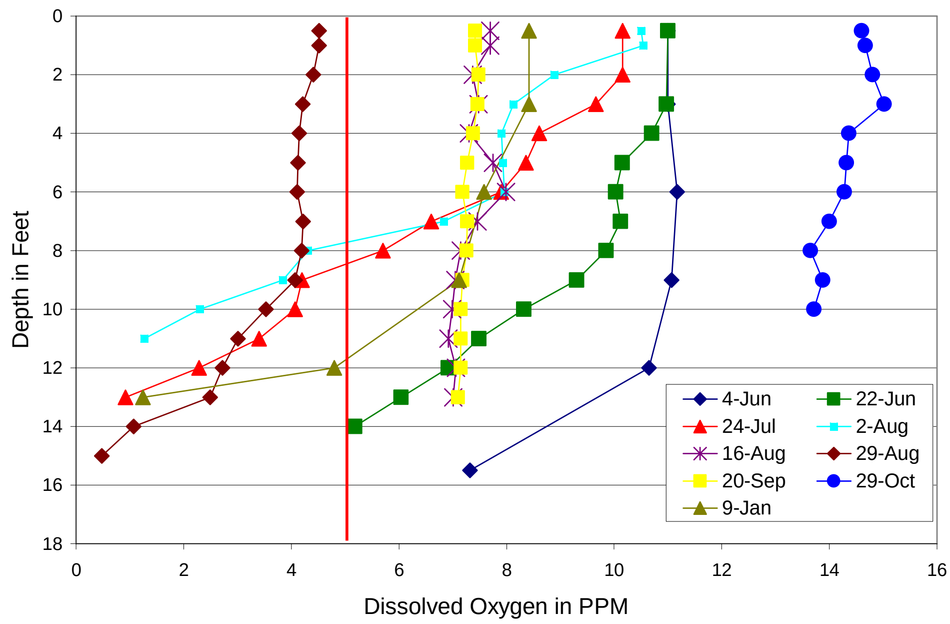


Figure 12. Summary of Dissolved Oxygen Concentrations for the Pheasant Lake Deepest Area Site (381125).

The deepest area of Pheasant Lake also had periods of low dissolved oxygen concentrations on these same dates, as well as on January 9. The dissolved oxygen concentrations at the deepest area site dropped below 5.0 mg L^{-1} between a depth of 8 and 12 feet on July 24, August 2 and January 9. The entire water column thermally stratified on August 29.

1.5.5 Secchi Disk In-Lake and Total Suspended Solids

Secchi disk depth data was collected by the James River SCD staff between June 2001 and February 2002. As shown in Table 8 secchi depths appear to be greatest in June with values ranging from 1.70-2.70 meters. As summer continues secchi depth appears to decrease to its lowest depths in August with values ranging 0.3-0.7 meters, and then rebounding in October where it increases to a reading of 1.40 meters. Available data indicates a rise in trophic condition during the warmest and most productive period of the year.

Table 8. Summary of Secchi Depths in Pheasant Lake (2001-2002).

Inlet Site (381127)		**Mid-Lake Site (385094)**		**Deepest Site (381125)**	
Date	Average Secchi Depth (M)	Date	Average Secchi Depth (M)	Date	Average Secchi Depth (M)
6/4/2001	2.70	6/4/2001	2.70	6/4/2001	1.70
6/22/2001	no sample	6/22/2001	no sample	6/22/2001	no sample
7/25/2001	1.20	7/25/2001	1.60	7/25/2001	1.30
8/2/2001	0.9	8/2/2001	1.10	8/2/2001	1.00
8/16/2001	no sample	8/16/2001	0.3	8/16/2001	0.7
8/29/2001	0.8	8/29/2001	0.9	8/29/2001	0.6
9/20/2001	1.10	9/20/2001	0.9	9/20/2001	0.8
10/29/2001	no sample	10/29/2001	1.40	10/29/2001	1.40

Since there are some inconsistencies in the available data due to missed samples (Table 8) the chlorophyll-a and secchi disk TSI (Table 12) will be used as an indicator of trophic status for the reservoir. Justification for using the chlorophyll-a and secchi disk TSI is given in Carlson and Simpson (1996). According to Carlson and Simpson secchi disk and chlorophyll-a TSI's are usually close in a shallow and nutrient loaded reservoir because most of the depth is related to algae in the water.

Pheasant Lake's hydraulic total suspended solids (TSS) budget was estimated using upstream flows on the Elm River (385083), Northwest Tributary (385082), West Northwest Tributary (385081), West Tributary (385080), and the Outlet (380017). Results can be found in Table 9.

Table 9. Total Suspended Solids Balance for Pheasant Lake (2001-2002).

	Inflow (kg)	**Outflow (kg)**	**Storage (kg)**
Total Suspended Solids	44,960.80	74,660.07	-29,699.90

1.5.6 Tributary Total Suspended Solids

Total suspended solids (TSS) samples were collected by the James River SCD staff between March-October 2001. The number of samples taken varied from each site due to lack of flow (Table 10, Figures 13-17).

When comparing total suspended solids (TSS) concentrations to the flow regimen of the tributaries (Figures 13-17), it appears that the peaks of TSS do not correlate well with the actual flows at that time. It appears that peaks in TSS concentations may be due more to algal biomass than that of mineralized sediment. Further evidence can be found by comparing inflow TSS loading to that of outflow TSS loading (Table 9). Based on data collected in 2001-2002, 44,960.80 kg of TSS entered the lake while 74,660.07 kg left the lake through the outlet resulting in a negative lake storage (-29,699.90 kg). These results can also be closely related to algal productivity in the lake instead of sediment accumulation. Based on these results a sediment TMDL will not be addressed in this particular document, but will be addressed at a later time when sufficient research into a sediment target for North Dakota rivers and streams is established.

Table 10. Average Total Suspended Solids Concentrations for the Pheasant Lake (2001-2002).

Site ID	Site Description	N	Average TSS (mg L^{-1})
385083	Elm River	28	5.2
385082	Northwest Tributary	25	5.4
385081	West Northwest Tributary	19	4.9
385080	West Tributary	17	22.6

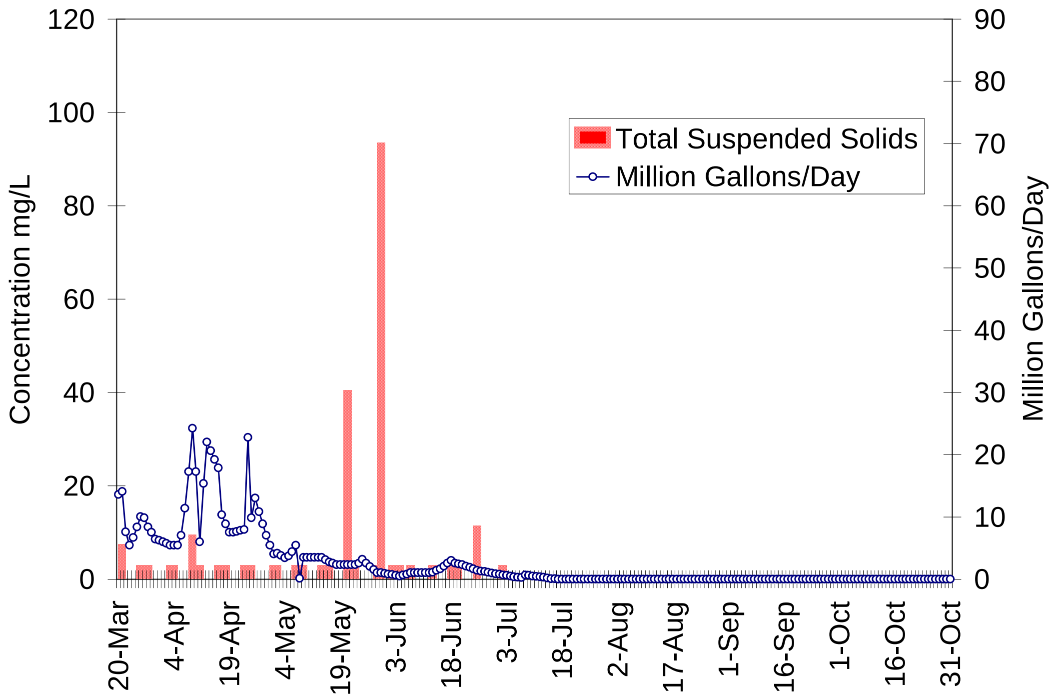


Figure 13. Elm River (385083) Total Suspended Solids Concentrations and Hydraulic Discharge.

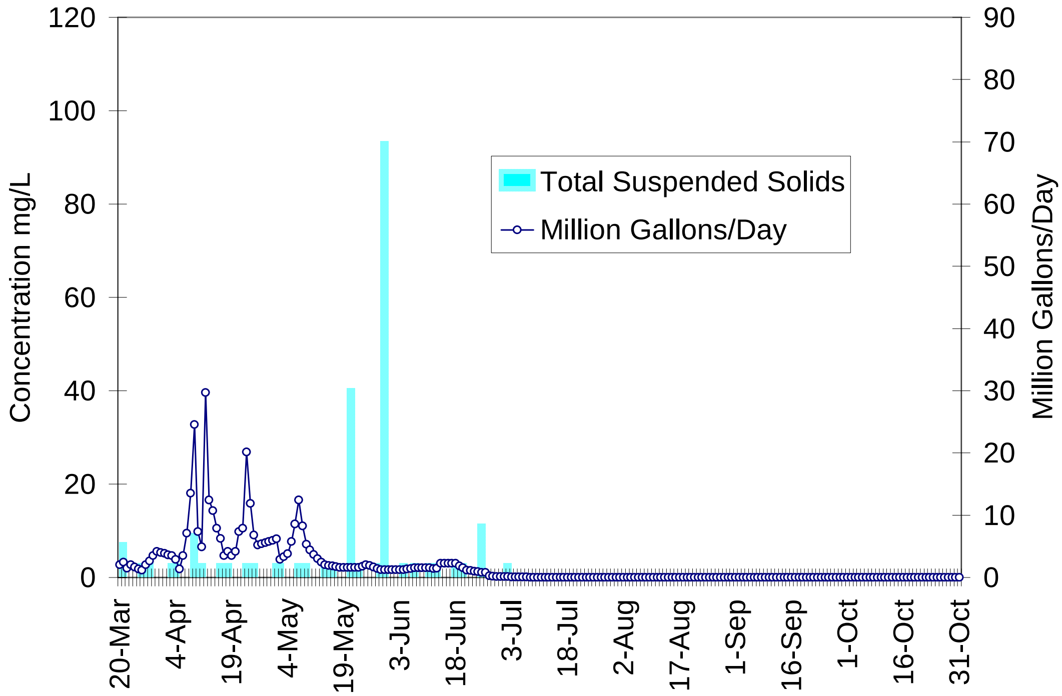


Figure 14. Northwest Tributary (385082) Total Suspended Solids Concentrations and Hydraulic Discharge.

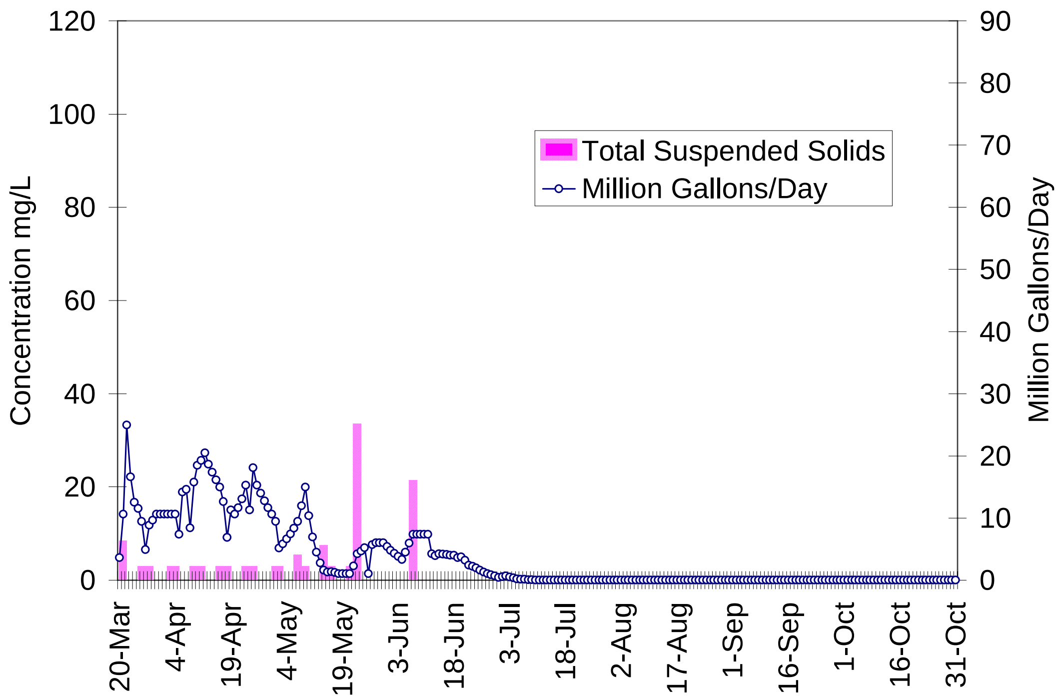


Figure 15. West Northwest Tributary (385081) Total Suspended Solids Concentrations and Hydraulic Discharge.

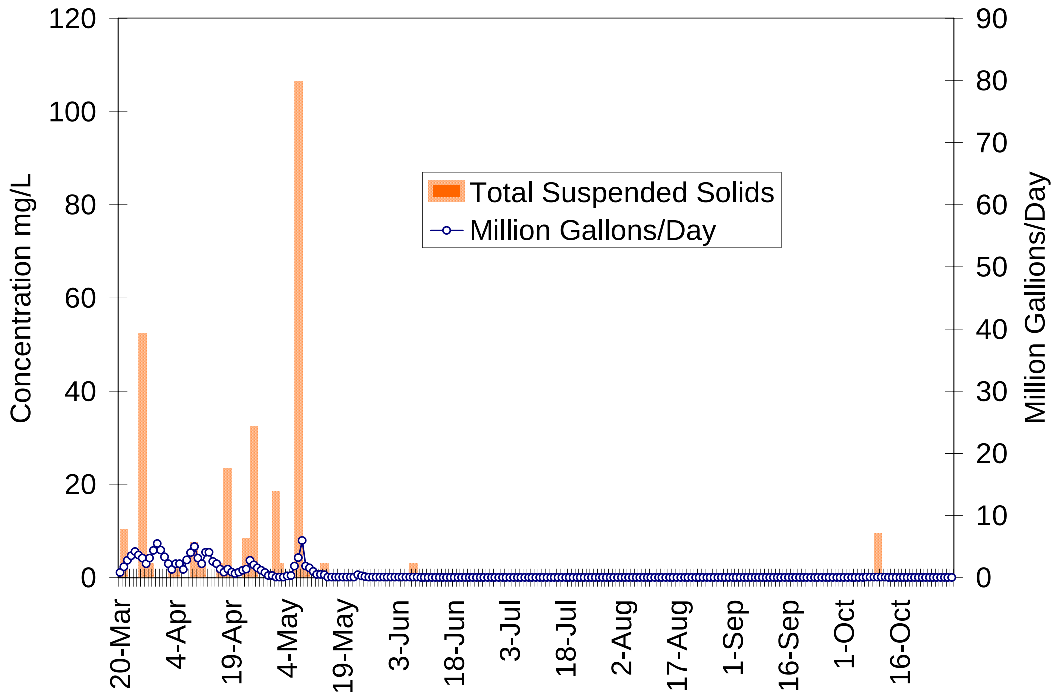


Figure 16. West Tributary (385080) Total Suspended Solids Concentrations and Hydraulic Discharge.

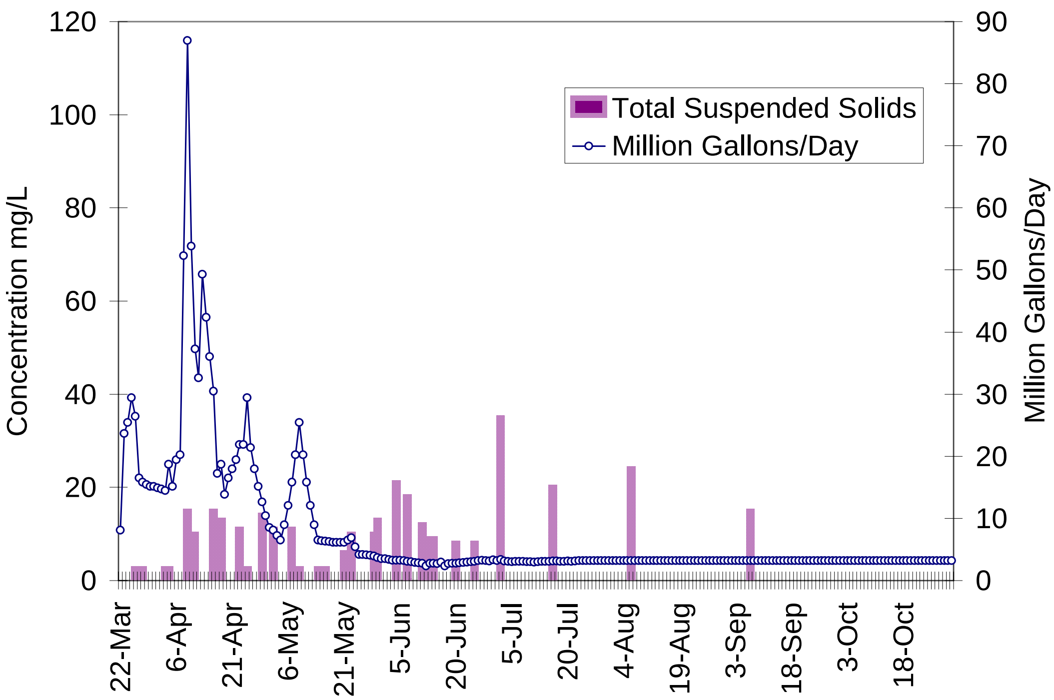


Figure 17. Pheasant Lake Outlet (380017) Total Suspended Solids Concentrations and Hydraulic Discharge.

2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's Section 303(d) list. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. The purpose of a TMDL is to identify the pollutant load reductions or other actions that should be taken so that impaired waters will be able to attain water quality standards. TMDLs are required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. Separate TMDLs are required to address each pollutant or cause of impairment (i.e., nutrients, sediment).

2.1 Narrative Water Quality Standards

The North Dakota Department of Health has set narrative water quality standards, which apply to all surface waters in the state. The narrative standards pertaining to nutrient impairments are listed below (NDDoH, 2001).

- All waters of the state shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutants, which alone or in combination with other substances shall:
    1) Cause a public health hazard or injury to environmental resources;
    2) Impair existing or reasonable beneficial uses of the receiving waters; or
    3) Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDoH has set a biological goal for all surface waters in the state. The goal states that "the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites," (NDDoH, 2001)

2.2 Numeric Water Quality Standards

Pheasant Lake is classified as a Class 3 warm water fishery. Class 3 fisheries are defined as waterbodies "capable of supporting growth and propagation of nonsalmonid fishes and associated aquatic biota" (NDDoH, 1991). All classified lakes in North Dakota are assigned aquatic life, recreation, irrigation, livestock watering, and wildlife beneficial uses. The North Dakota State Water Quality Standards state that lakes shall use the same numeric criteria as Class 1 streams. This includes the state standard for dissolved oxygen set at no less than 5 mg L^{-1}. State standards for lakes and reservoirs also specify guidelines for nitrogen (1.0 mg L^{-1} as nitrate) and phosphorus (0.1 mg L^{-1} as total phosphorus) (Table 11).

Table 11. Numeric Standards Applicable for North Dakota Lakes and Reservoirs (NDDoH , 2001).

Parameter		Guidelines	Limit
Guidelines for Classified Lakes			
	Nitrates (dissolved)	1.0 mg L^{-1}	Maximum allowed[1]
	Phosphorus (total)	0.1 mg L^{-1}	Maximum allowed[1]
	Dissolved Oxygen	5 mg L^{-1}	Not less than
Guidelines for goals in a lake improvement or maintenance program			
	NO_3 as N	0.25 mg L^{-1}	Goal
	PO_4 as P	0.02 mg L^{-1}	Goal

[1] **"Interim guideline limits"**

3.0 TMDL TARGETS

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets should be based on state water quality standards, but can also include site-specific values when no numeric criteria are specified in the standard. The following sections summarize water quality targets for Pheasant Lake based on its beneficial uses. If the specific target is met, it is assumed the reservoir will meet the applicable water quality standards, including its designated beneficial uses.

3.1 Nutrient Target

North Dakota's 2004 Integrated Section 305(b) Water Quality Assessment Report indicates that Carlson's Trophic State Index (TSI) is the primary indicator used to assess beneficial uses of the state's lakes and reservoirs (NDDoH, 2004). Trophic status is the measure of productivity of a lake or reservoir and is directly related to the level of nutrients (phosphorus and nitrogen) entering the lake or reservoir from its watershed. Lakes tend to become eutrophic (more productive) with higher nitrogen and phosphorus inputs. Eutrophic lakes often have nuisance algal blooms, limited water clarity, and low dissolved oxygen concentrations that can result in impaired aquatic life and recreational uses. Carlson's TSI attempts to measure the trophic state of a lake using nitrogen, phosphorus, chlorophyll-a, and Secchi disk depth measurements (Carlson, 1977).

A Carlson's TSI target of 58.50 for chlorophyll-a and 52.25 for secchi disk was chosen for the Pheasant Lake endpoint. Each TSI score was found using water quality data collected from the deepest site (381125), then averaged for each indicator (Chl-a, TP, SD) and finally calculated for a TSI value. Based on Carlson's TSI and water quality data collected between March 2001 and February 2002, Pheasant Lake was generally assessed as a eutrophic lake (Table 12). Eutrophic lakes are characterized by large growths of weeds, bluegreen algal blooms, and low dissolved oxygen concentrations. These lakes experience frequent fish kills and are generally characterized as having excessive rough fish populations (carp, bullhead, sucker) and poor sport fisheries. Because of the frequent algal blooms and excessive weed growth, these lakes are also undesirable for recreational uses such as swimming and boating.

Table 12. Carlson's Trophic State Indices for Pheasant Lake.

Parameter	Relationship	Units	TSI Value	Trophic Status
Chlorophyll-a	TSI (Chl-a) = 30.6 + 9.81[ln(Chl-a)]	µg/L	60	Eutrophic
Total Phosphorus (TP)	TSI (TP) = 4.15 + 14.42[(ln(TP)]	µg/L	94	Hypereutrophic
Secchi Depth (SD)	TSI (SD) = 60 - 14.41[ln(SD)]	meters	60	Eutrophic
Total Nitrogen (TN)	TSI (TN) = 54.45 + 14.43[ln(TN)]	mg/L	60	Eutrophic

TSI < 25 - Oligotrophic (least productive) TSI 25-50 Mesotrophic
TSI 50-75 Eutrophic TSI > 75 - Hypereutrophic (most productive)

The reasons for the different TSI values estimated for Pheasant Lake are varied. According to the total phosphorus TSI value, Pheasant Lake is an extremely productive lake (hypereutrophic) (Figure 18). Carlson and Simpson (1996) suggest that if the phosphorus and secchi depth TSI values are relatively similar and higher than the chlorophyll-*a* TSI value, then dissolved color or nonalgal particulates dominate light attenuation. It follows that, as is the case with Dead Colt Creek Dam, if the secchi depth and chlorophyll-*a* TSI values are similar, then chlorophyll-*a* is dominating light attenuation. Carlson and Simpson (1996) also stated that, "If data for chlorophyll and phosphorus are available, use chlorophyll as the primary index for trophic state classification. Use the deviations of the Secchi depth and total phosphorus indices from the chlorophyll index to infer additional information about the functioning of the lake." (Table 13)

Table 13. Relationships Between TSI Variables and Coditions.

Relationship Between TSI Variables	Conditions
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(Chl) > TSI(SD)	Large particulates, such as *Aphanizomenon* flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.

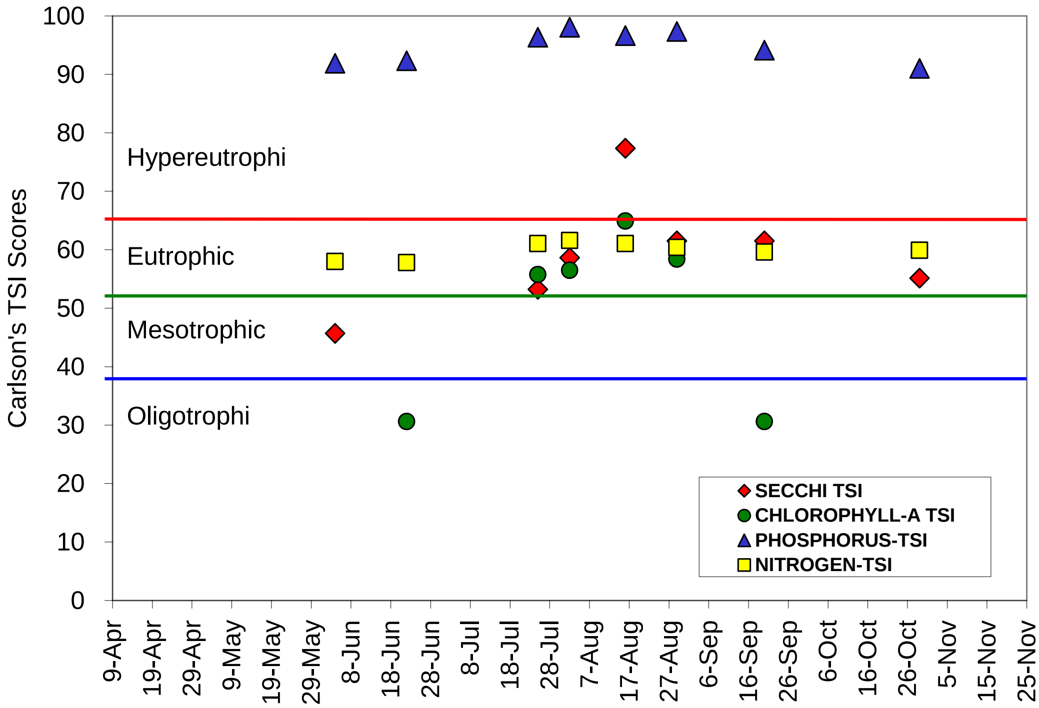


Figure 18. Temporal distribution of Carlosn's Trophic Status Index scores for Pheasant Lake.

Therefore if the specified TMDL TSI targets of 58.50 for chlorophyll-a and 52.25 for secchi disk are met, the reservoir can be expected to meet and maintain the applicable water quality standards for aquatic life and recreational beneficial uses.

3.2 Dissolved Oxygen Target

The North Dakota State Water Quality Standard for dissolved oxygen is “no less than 5.0 mg/L^{-1}” and will be the dissolved oxygen target for Pheasant Lake

4.0 SIGNIFICANT SOURCES

There are no known point sources upstream of Pheasant Lake. The pollutants of concern originated from non-point sources.

5.0 TECHNICAL ANALYSIS

Establishing a relationship between in-stream water quality targets and pollutant source loading is a critical component of TMDL development. Identifying the cause-and-effect relationship between pollutant loads and the water quality response is necessary to evaluate the loading capacity of the receiving waterbodies. The loading capacity is the amount of a pollutant that can be assimilated by the waterbody while still attaining and maintaining water quality standards. This section discusses the technical analysis used to estimate existing loads to Pheasant Lake and the predicted trophic response of the reservoir to reductions in loading capacity.

5.1 Tributary Load Analysis

To facilitate the analysis and reduction of tributary inflow and outflow water quality and flow data, the FLUX program was employed. The FLUX program, also developed by the US Corps of Engineers Waterways Experiment Station (Walker, 1996), uses six calculation techniques to estimate the average mass discharge or loading that passes a given river or stream site. FLUX estimates loadings based on grab sample chemical concentrations and the continuous daily flow record. Load is therefore defined as the mass of a pollutant during a given time period (e.g., hour, day, month, season, year). The FLUX program allows the user, through various iterations, to select the most appropriate load calculation technique and data stratification scheme, either by flow or date, which will give a load estimate with the smallest statistical error, as represented by the coefficient of variation. Output from the FLUX program is then provided as an input file to calibrate the BATHTUB eutrophication response model. For a complete description of the FLUX program the reader is referred to Walker (1996).

5.2 BATHTUB Trophic Response Model

The BATHTUB model (Walker, 1996) was used to predict and evaluate the effects of various nutrient load reduction scenarios on Pheasant Lake. BATHTUB performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network. The model accounts for advective and diffusive transport and nutrient sedimentation. Eutrophication related water quality conditions are predicted using empirical relationships previously developed and tested for reservoir applications.

The BATHTUB model is developed in three phases. The first two phases involve the analysis and reduction of the tributary and in-lake water quality data. The third phase involves model calibration. In the data reduction phase, the in-lake and tributary monitoring data collected as part of the project were summarized in a format which can serve as inputs to the model.

The tributary data were analyzed and reduced by the FLUX program. FLUX uses tributary inflow and outflow water quality and flow data to estimate average mass discharge, or loading that passes a river or stream site using six calculation techniques. Load is therefore defined as the mass of pollutant during a given unit of time. In the case of the Pheasant Lake the FLUX program came up with mass load of nutrients and total suspended solids for each subwatershed based on a time of 0.62 years (Table 14). The FLUX model then allows the user to pick the most appropriate load calculation technique with the smallest statistical error. Output for the FLUX program is then used to calibrate the BATHTUB model.

Table 14. Mass Load of Nutrients and Total Suspended Solids for the Pheasant Lake Subwatersheds.

Station	Time (yrs)	Units	Nitrate+ Nitrite	Total Nitrogen	Total Phosphorus	Suspended Solids
Elm River (385083)	0.62	kg	1,224	4,565	1,573	11,415
Northwest Tributary (385082)	0.62	kg	704	3,076	597	8,332
West Northwest Tributary (385081)	0.62	kg	1,576	5,513	1,043	15,049
West Tributary (385080)	0.62	kg	422	968	167	10,165
Outlet (380017)	0.62	kg	6,750	26,743	6,369	71,756

The reservoir data were reduced in Excel using three computational functions. These include: 1) the ability to display concentrations as a function of depth, location, or date; 2) summary statistics (mean, median, etc.); and 3) an evaluation of trophic status. The output data from the Excel program were then used to calibrate the BATHTUB model.

When the output data from FLUX and Excel programs are entered into the BATHTUB model the user has the ability to compare predicted conditions (model output) to actual conditions using general rates and factors. The BATHTUB model is then calibrated by combining tributary load estimates for the project period with in-lake water quality estimates. The model is termed calibrated when the predicted estimates for the trophic response variables are similar to observed estimates from the project monitoring data. BATHTUB then has the ability to predict total phosphorus concentration, chlorophyll-a concentration, and secchi disk transparency and the associated TSI scores as a means of expressing trophic response.

As stated above, BATHTUB can compare predicted vs. actual conditions. After calibration, the model was run based on observed concentrations of total phosphorus and total nitrogen, to derive an estimated annual average total phosphorus load of 3,380 kg and an annual average total nitrogen load of 14,122 kg. The model was then run to evaluate the effectiveness of a number of nutrient reduction alternatives including; (1) reducing externally derived nutrient loads; (2) reducing internally available nutrients; and (3) reducing both external and internal nutrient loads.

In the case of Pheasant Lake, BATHTUB modeled two nutrient reduction alternatives. The first alternative reduced externally derived phosphorus and nitrogen. Phosphorus was used in the initial set of simulation models based on its known relationship to eutrophication and that it is controllable with the implementation of watershed Best Management Practices (BMPs) or lake restoration methods. Simulated reductions were achieved by reducing concentrations of instream nutrients by 25, 50, 75, and 90 percent without changing the hydraulics entering and exiting the lake. The target set for this simulation is a trophic response within Carlson's TSI range of eutrophic, using chlorophyll-a and secchi disk as the indicators.

Alternative one estimated that a 50 percent reduction in external phosphorus and nitrogen loading to Pheasant Lake would decrease the Carlson's TSI score for chlorophyll-a and secchi disk to less than 60 achieving a trophic response.

Table 15. Observed and Predicted Values for Selected Trophic Response Variables Assuming a 25, 50,75 and 90 Percent Reduction in External Phosphorus and Nitrogen Loading.

Variable	Observed Value	Predicted Value			
		25%	50%	75%	90%
Total Phosphorus (mg/L)	0.545	0.461	0.365	0.242	0.138
Total Nitrogen (mg/L)	1.468	1.228	1.004	0.649	0.366
Conservative Nutrient (mg/L)	0.108	0.088	0.070	0.041	0.018
Chlorophyll-a (µg/L)	19.25	16.67	13.78	8.23	3.16
Secchi Disk Transparency (meters)	0.96	1.04	1.24	1.89	3.65
Carlson's TSI for Phosphorus	95.01	92.58	89.21	83.29	75.21
Carlson's TSI for Chlorophyll-a	59.61	58.20	56.33	51.28	41.90
Carlson's TSI for Secchi Disk	60.59	59.49	56.85	50.79	41.33

To acquire a noticeable change in the tropic status the BATHTUB model predicted that a 50 percent reduction in external total phosphorus and nitrogen loads would achieve the target of 0.365 mg L^{-1} and 1.004 mg L^{-1} (Table 15). This reduction in phosphorus and nitrogen is predicted to result in a chlorophyll-a and secchi disk TSI score in the eutrophic range (Figure 19).

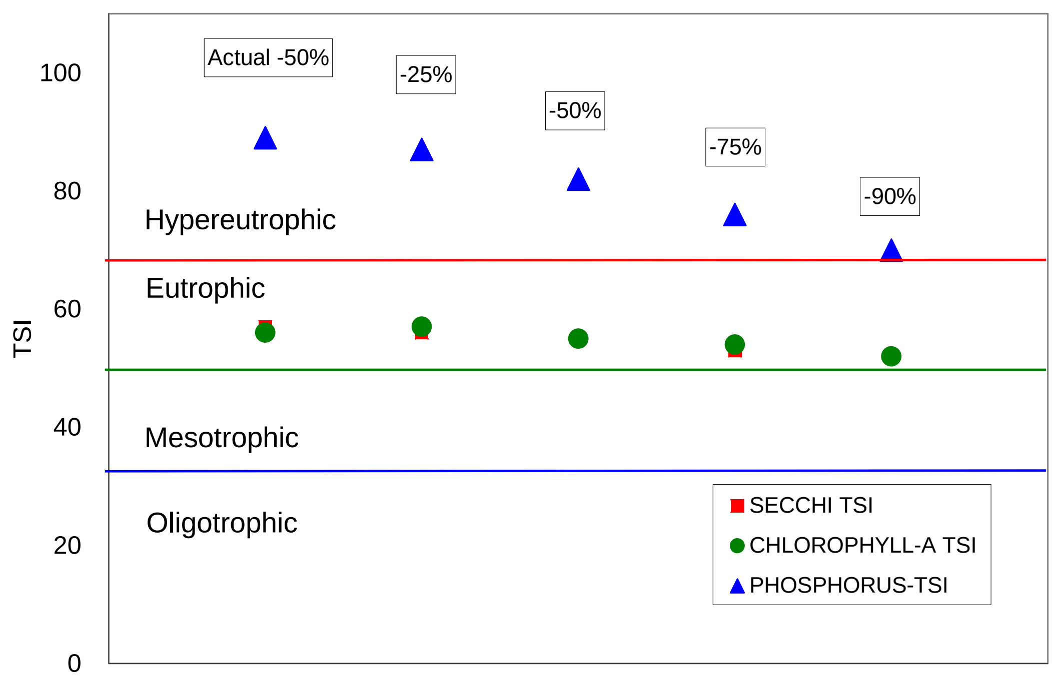


Figure 19. Predicted Trophic Response to External Total Phosphorus and Total Nitrogen Load Reductions to Pheasant Lake of 25, 50, 75 and 90 Percent.

Alternative two simulated internal and external nutrient load. This simulation assumed a base lake condition resulting from a 50 percent reduction in external load (predicted in alternative one) and decreases in internally available phosphorus and nitrogen of 25, 50, 75, and 90 percent. As with the first set of simulations, the hydraulic inflow and outflow remained constant. The model results indicated insignificant gain in controlling internally stored nutrients, even a 90 percent reduction in internal load netted only a minimal trophic response (Table 16, Figure 20). This simulation indicates that Pheasant Lake's trophic condition is externally driven.

Table 16. Observed and Calibrated Trophic Response Model Variables Assuming a 25, 50, 75, and 90 Percent Reduction in Internal Available Total Phosphorus and Total Nitrogen.

Variable	External Reduction -50% Calculated	Predicted Value Internal Reduction 25%	50%	75%	90%
Total Phosphorus (mg/L)	0.365	0.291	0.217	0.143	0.099
Total Nitrogen (mg/L)	1.004	0.941	0.880	0.813	0.775
Conservative Nutrient (mg/L)	0.070	0.640	0.59	0.052	0.046
Chlorophyll-a (µg/L)	13.78	12.79	11.75	10.38	9.30
Secchi Disk Transparency (meters)	1.24	1.33	1.43	1.58	1.73
Carlson's TSI for Phosphorus	89.21	85.96	81.75	75.72	70.45
Carlson's TSI for Chlorophyll-a	56.33	55.60	54.77	53.56	52.47
Carlson's TSI for Secchi Disk	56.85	55.89	54.85	53.38	52.12

Two factors affecting internally available nutrients within Pheasant Lake are an aeration system and hypolimnetic draw down. The aeration system is normally operational for the duration of the ice-covered period, and the hypolimnetic draw down is opened in late winter or early spring and allowed to run through late spring or early summer, depending on lake levels. In combination, the two systems prevent the lake from thermally stratifying, thereby reducing internal cycling of nutrients and discharging nutrient-rich waters from the hypolimnion.

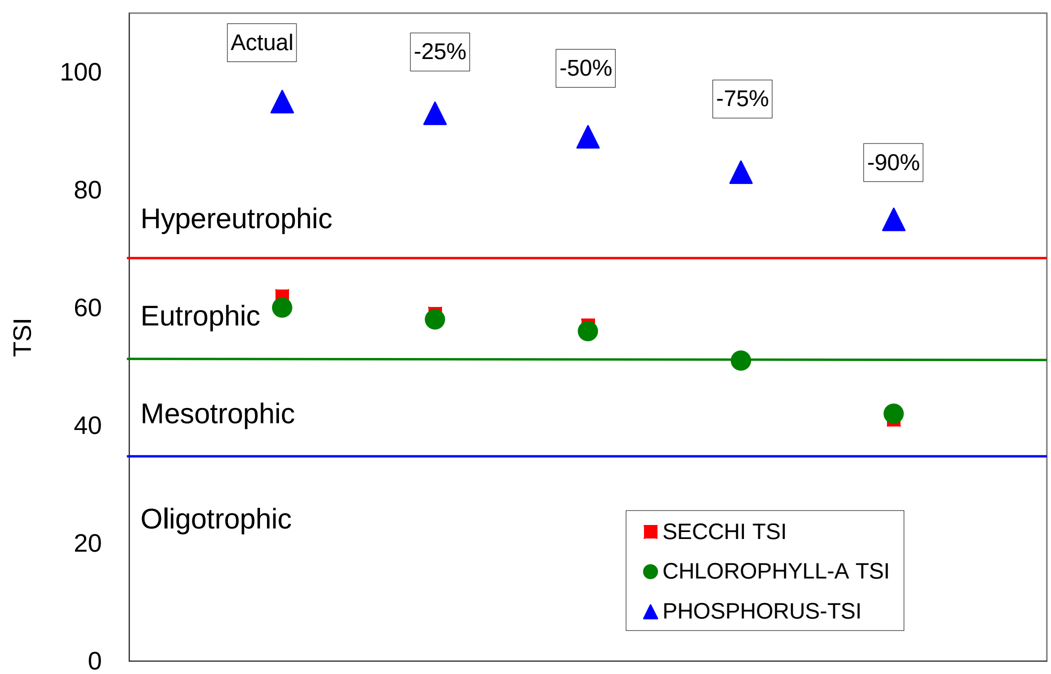


Figure 20. Predicted Trophic Response to Reductions in External Nitrogen and Phosphorus Load of 50 Percent and Internal Available Nitrogen and Phosphorus of 25, 50, 75, and 90 percent.

5.3 AGNPS Watershed Model

In order to identify significant NPS pollutant sources in the Pheasant Lake watershed and to assess the relative reductions in nutrient (nitrogen and phosphorus) and sediment loading that can be expected from the implementation of BMPs in the watershed , an AGNPS 3.65 Model analysis was employed.

The primary objectives for using the AGNPS 3.65 model were to: 1) evaluate NPS contributions within the discrete subwatersheds; 2) identify critical pollutant source areas within the subwatersheds; and 3) evaluate impacts from livestock concentration areas individually and as total impact.

The AGNPS 3.65 model is a single event model that has twenty input parameters. Fifteen parameters were used to calculate nutrient/sediment output, animal feeding operation inventories, surface runoff, and erosion. The parameters used were receiving cell, aspect, SCS curve, percent slope, slope shape, slope length, Manning's roughness coefficient, C-factor, P-factor, surface conditions constant, soil texture, fertilizer inputs, point source indicators, COD factor and channel indicator.

The AGNPS 3.65 model was used in conjunction with an intensive land use survey to determine critical areas within the Pheasant Lake watershed. Criteria used during the landuse assessment were percent cover on cropland and pasture/range conditions. These criteria were used to determine the C factor for each cell. The model was run using current conditions determined during the land use assessment. Other than the low density urban development around Pheasant Lake, the land use survey required for AGNPS data input files identified that 100 percent of the watershed is in agricultural production or in support of agricultural production such as farmsteads and farm-to-market roads. The principal uses included pasture, row crops, small grain, alfalfa/hay, CRP, fallow ground and wetlands or streams. Additionally, the land survey identified 33 farmsteads and 15 concentrated livestock holding areas.

A 25-year precipitation event of 4 inches in 24 hours was chosen for evaluation purposes. The model subdivided the Pheasant Lake Watershed into 1,524, 40-acre cells or 60,940 acres for evaluation. Each cell was evaluated for soil characteristics, terrain, and land-use characteristics.

The AGNPS model subwatersheds are located at approximately the same locations as the water quality monitoring stations: Elm River (385083), Northwest Tributary (385082), West Northwest Tributary (385081), and West Tributary (385080). The AGNPS model results per subwatershed include: 1) acres, 2) hydraulic delivery in inches per acre, 3) peak runoff rate in cubic feet per second (cfs), 4) nitrogen in sediment delivery, 5) dissolved nitrogen delivery, 6) soluble nitrogen concentration in run-off in mg L^{-1}, 7) phosphorus delivery, 8) dissolved phosphorus delivery, and 9) dissolved phosphorus concentration in runoff in mg L^{-1}.

Table 17 shows the AGNPS modeled peak runoff in cubic feet per second (cfs) for the subwatersheds of Pheasant Lake. Values ranged from a low of 1,766.19 cfs on the West subwatershed to a high of 5,907.47 cfs on the Elm River subwatershed. Each subwatershed was also modeled for inches of runoff. The Elm River, Northwest and West subwatersheds were marginally lower (1.78 to 1.81 inches) than the runoff for the West Northwest subwatershed of 1.90 inches. Nutrients and sediment delivery were also predicted, results can be found in Figures 21-30.

Table 17. AGNPS Modeled Subwatershed Size and Peak Runoff.

Subwatershed	Acres	Runoff	cfs
Elm River	23,880	1.80	5,907.42
Northwest	17,360	1.78	4,293.05
West Northwest	14,720	1.90	3,705.78
West	4,920	1.81	1,766.19

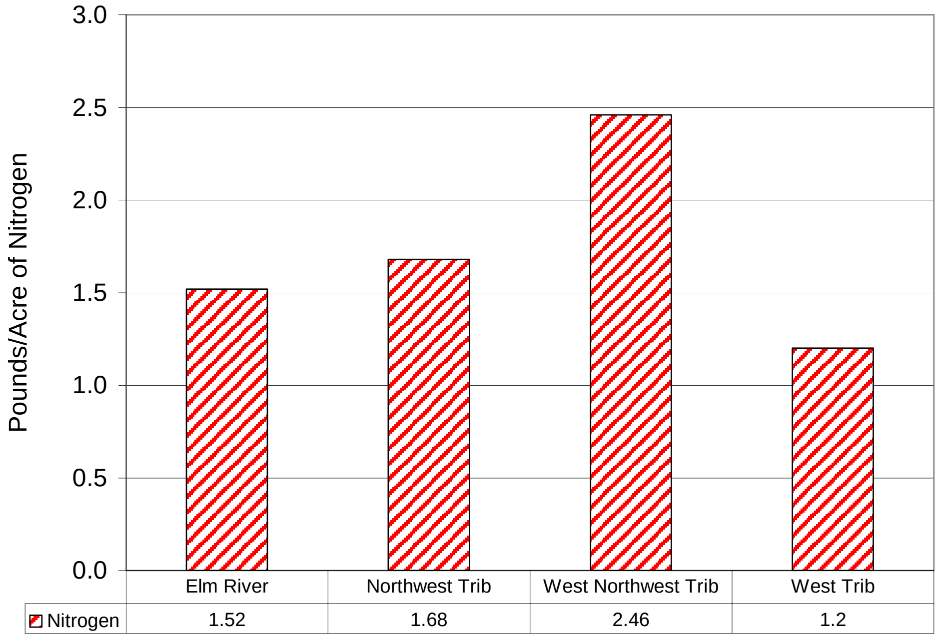


Figure 21. Pounds Per Acre of Total Nitrogen in Eroded Sediment from a 24-hour, 4-inch Rain Event on the Upstream Subwatersheds of Pheasant Lake.

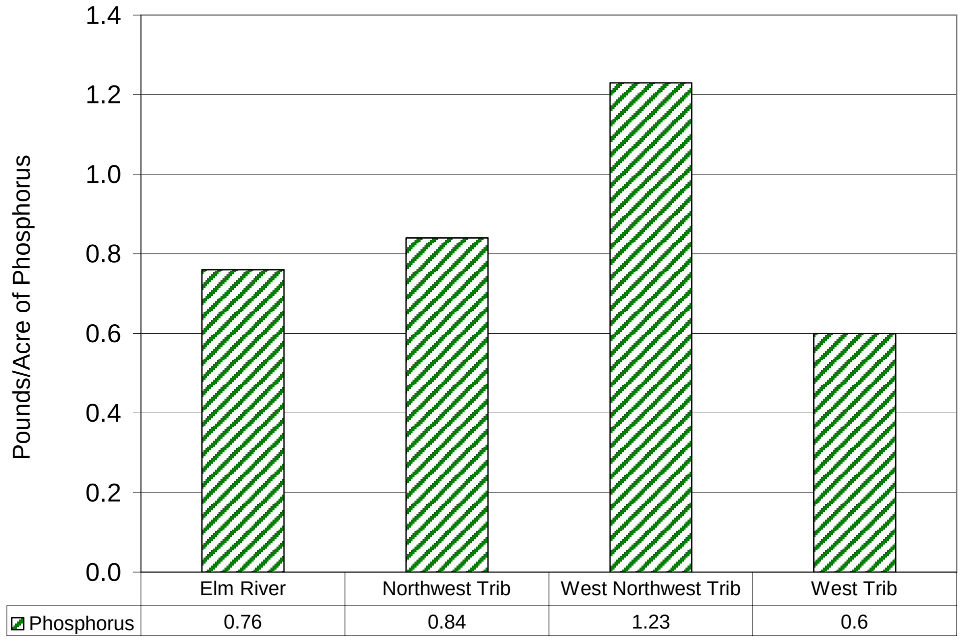


Figure 22. Pounds Per Acre of Total Phosphorus in Eroded Sediment from a 24-hour, 4-inch Rain Event on the Upstream Subwatersheds of Pheasant Lake.

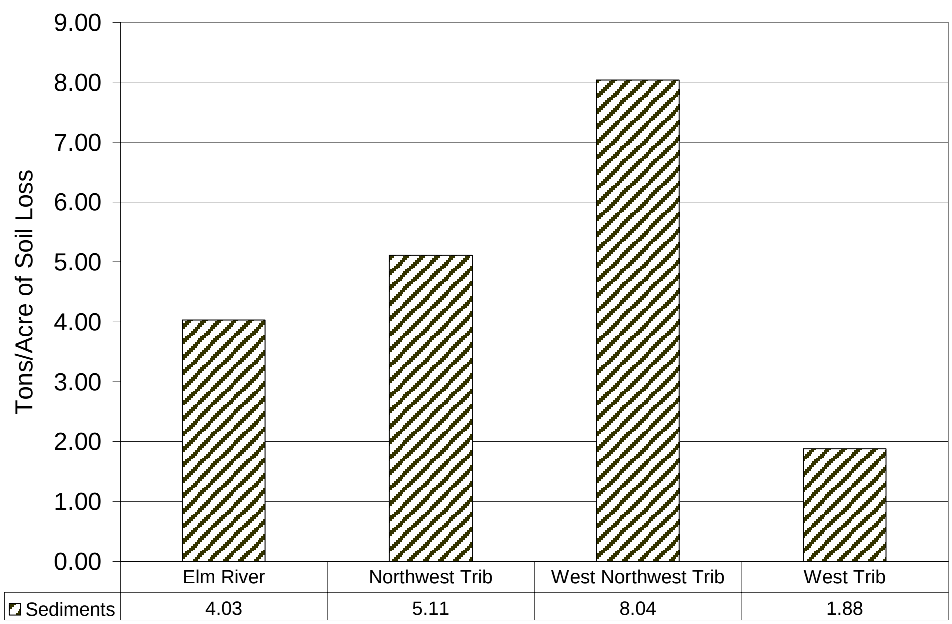


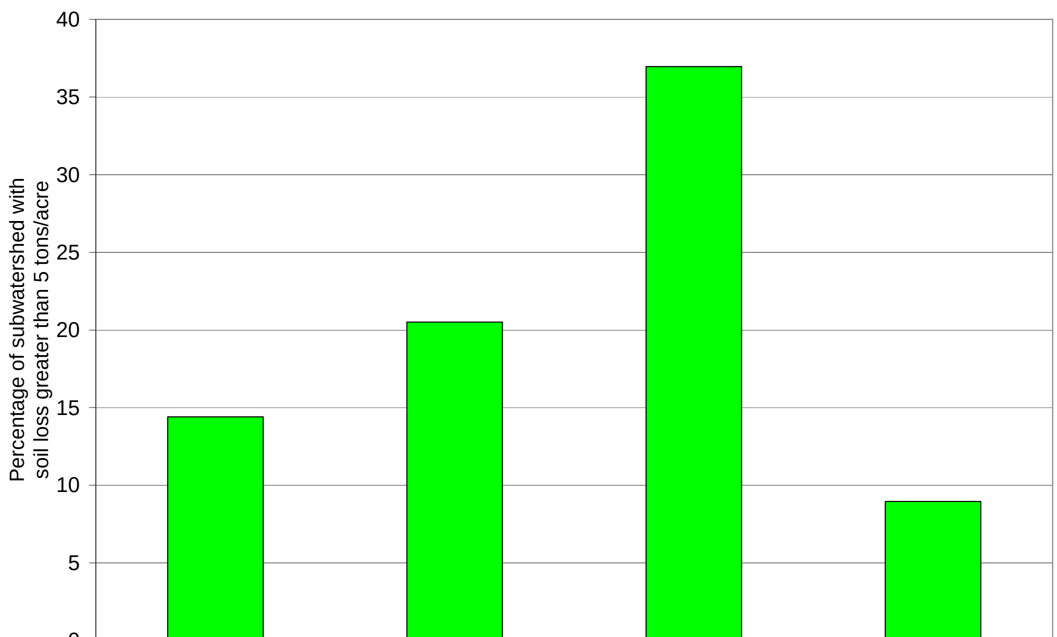
Figure 23. Tons Per Acre in Eroded Sediments from a 24-hour, 4-inch Rain Event on the Upstream Subwatersheds of Pheasant Lake.

Critical area per subwatershed was identified by modeling the potential for erosion and nutrient losses. The precipitation event entered into the model was a 4-inch, 24-hour rain event. Critical area was identified for sediment, nitrogen, and phosphorus yields. The critical area per subwatershed was divided into three groups for soil loss (critical, highly critical, and extremely critical) and two groups for nitrogen and phosphorus (critical and highly critical).

Sediment

For sediment loss, the critical area was defined as the percentage of acres per subwatershed with a predicted soil loss of 5 tons per acre and above, highly critical as 7 tons per acre and above and extremely critical as 10 tons per acre and above. For nitrogen; critical area was defined as the percentage of the subwatershed with predicted nitrogen yields in excess of 3 pounds per acre and highly critical as the percentage with yields of 5 pounds per acre or more. Highly critical areas for phosphorus were defined as the percentage of subwatershed with predicted phosphorus yields in excess of 1.5 pounds per acre and above, and highly critical as the percentage of the subwatershed with phosphorus yields of 3 pounds per acre or more. Critical areas were determined by plotting the landuse data gathered in the field and entered into AGNPS. This resulted in areas exhibiting similar traits (landuse, slope, etc.). These areas were then grouped together on the basis of low, medium, and high sediment loss and nutrients.

In general the subwatersheds critical area, based on soil loss, was consistent throughout the full range of critical, highly critical, and extremely critical gradations. The AGNPS model predicted that the West Northwest subwatershed had the largest percentage of area with soil loss in excess of 5, 7, and 10 tons per acre followed in descending order of percent critical area by the Northwest, Elm River, and West subwatersheds (Figures 21-23).



	Elm River	Northwest Trib	West Northwest Trib	West Trib
% > 5 ton	14.41	20.51	36.96	8.94

Figure 24. Percentage of Subwatersheds with AGNPS Model Predicted Soil Loss in Excess of 5 Tons Per Acre or Greater (Critical).

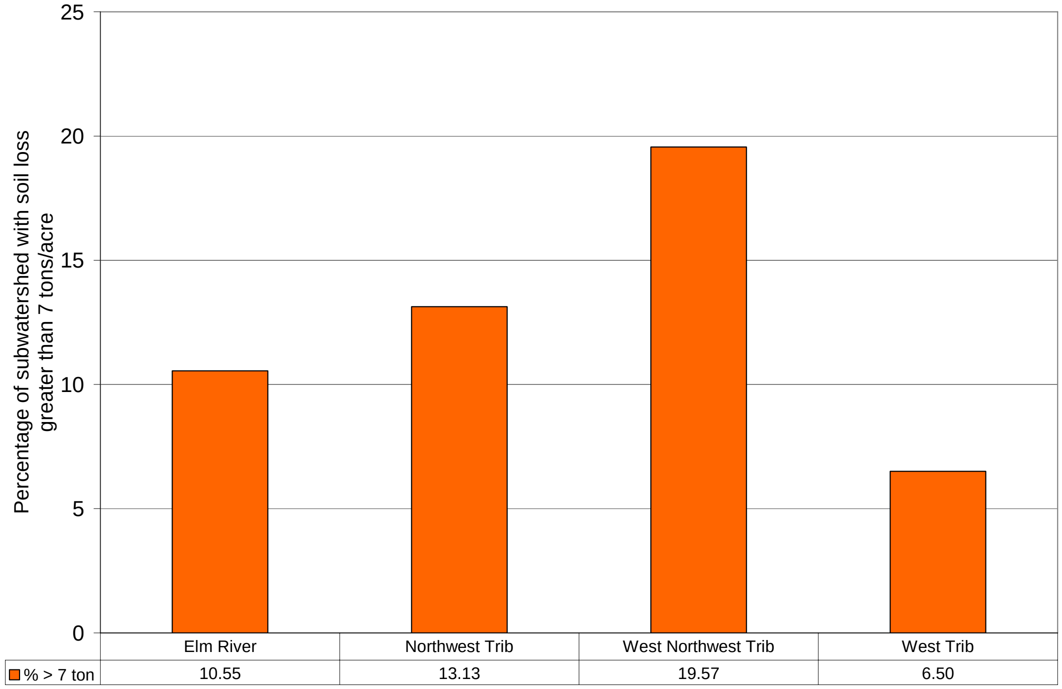


Figure 25. Percentage of Subwatersheds with AGNPS Model Predicted Soil Loss in Excess of 7 Tons Per Acre (Highly Critical).

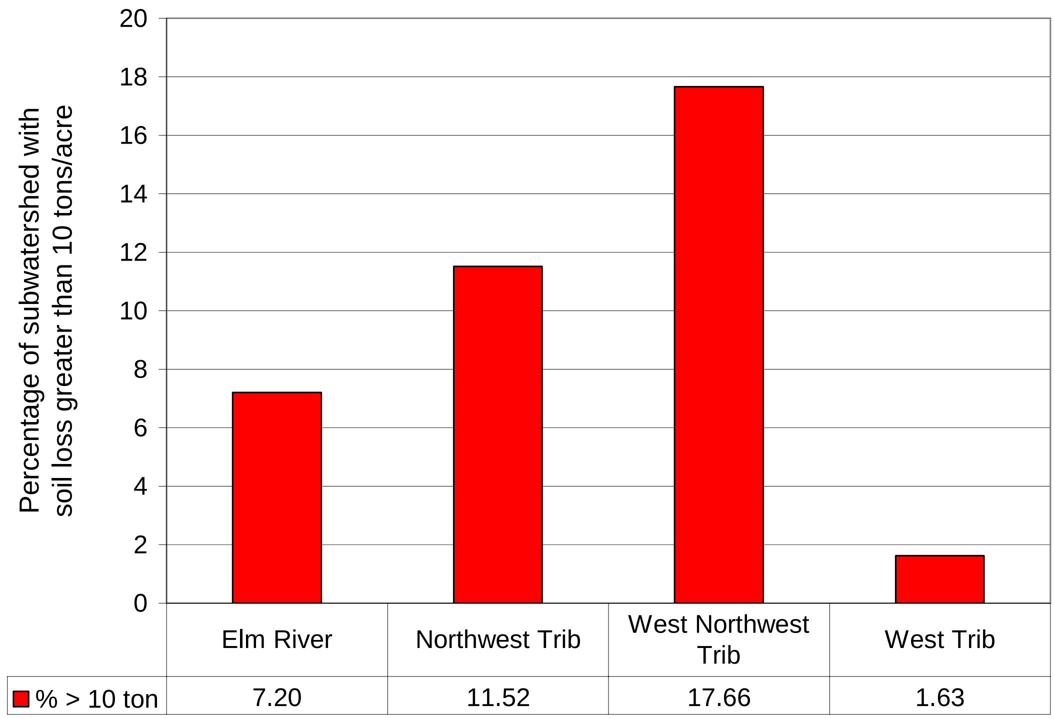
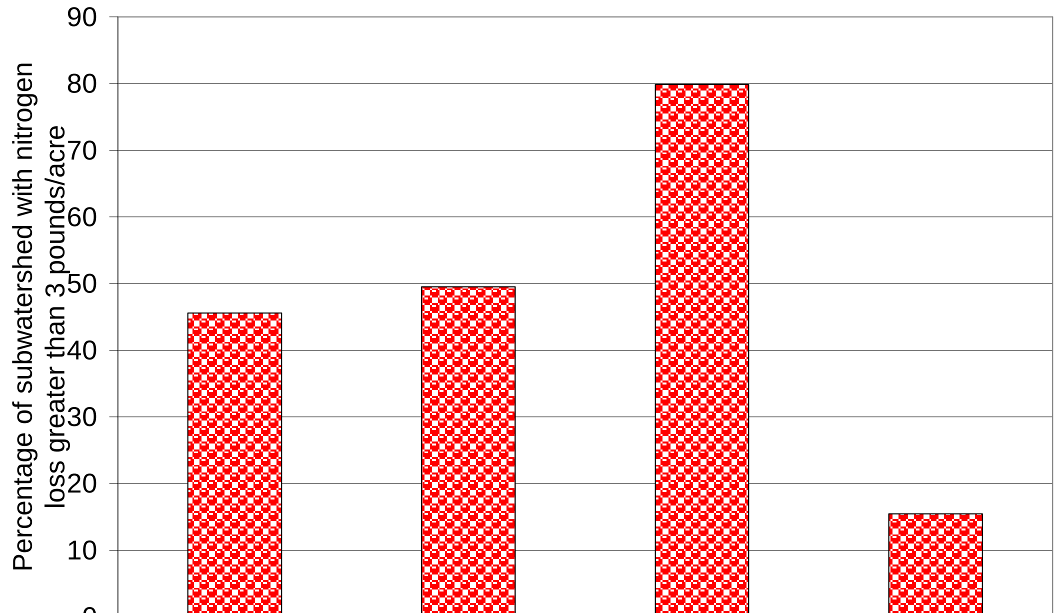


Figure 26. Percentage of Subwatersheds with AGNPS Model Predicted Soil Loss in Excess of 10 Tons Per Acre (Extremely Critical).

<u>Nutrients</u>

AGNPS modeled the percentage of subwatersheds with potential for nitrogen loss. Critical area ranged from critical (loss of 3 pounds per acre or above) or highly critical (loss of 5 pounds per acre or above) for nitrogen based on a single 4-inch 24-hour rain event (Figures 27 and 28). Values for critical areas with the potential of nitrogen loss ranged from 15.45 percent on the West subwatershed to a high of 79.89 percent on the West Northwest subwatershed. Highly critical areas for the potential for nitrogen loss values ranged from 3.25 percent in the West to 55.00 percent on the West Northwest subwatershed.

AGNPS also modeled the percentage of subwatersheds with the potential for phosphorus loss. Critical area ranged from critical (loss of 1.5 pounds per acre and above) to highly critical (loss of 3 pounds per acre and above) for phosphorus based on a single 4-inch 24-hour rain event (Figures 29, 30). Values for critical areas with the potential for phosphorus loss ranged from 13.82 percent on the West subwatershed to a high 67.12 percent on the West Northwest subwatershed. Highly critical areas for the potential for phosphorus loss values ranged from 3.25 percent on the West subwatershed to 45.11 percent on the West Northwest subwatershed.



	Elm River	Northwest Trib	West Northwest Trib	West Trib
% > 3 lbs	45.56	49.54	79.89	15.45

Figure 27. Percentage of Subwatersheds with AGNPS Model Predicted Nitrogen Loss in Excess of 3 pounds Per Acre (Critical).

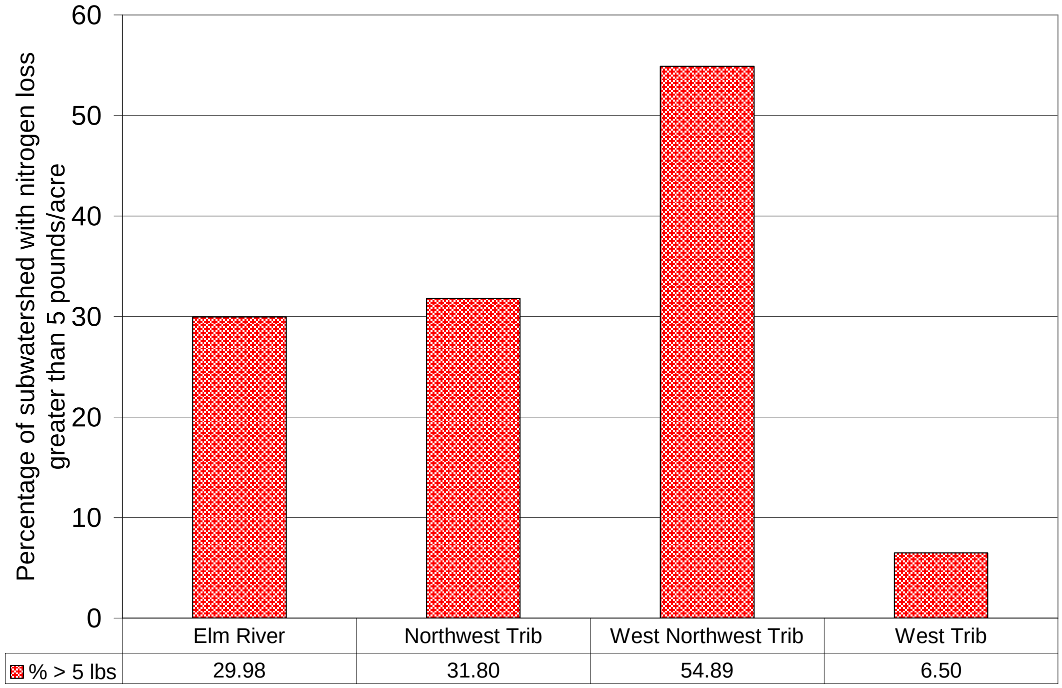


Figure 28. Percentage of Subwatesheds with AGNPS Model Predicted Nitrogen Loss in Excess of 5 pounds Per Acre (Highly Critical).

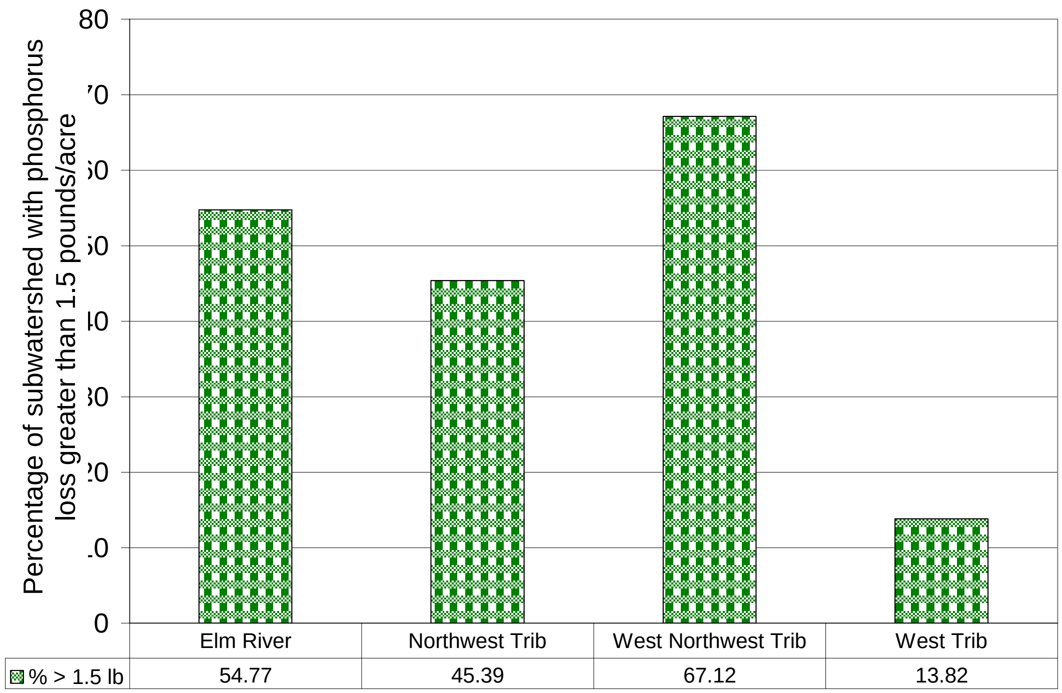


Figure 29. Percentage of Subwatershed with AGNPS Model Predicted Phosphorus Loss in Excess of 1.5 Pounds Per Acre (Critical).

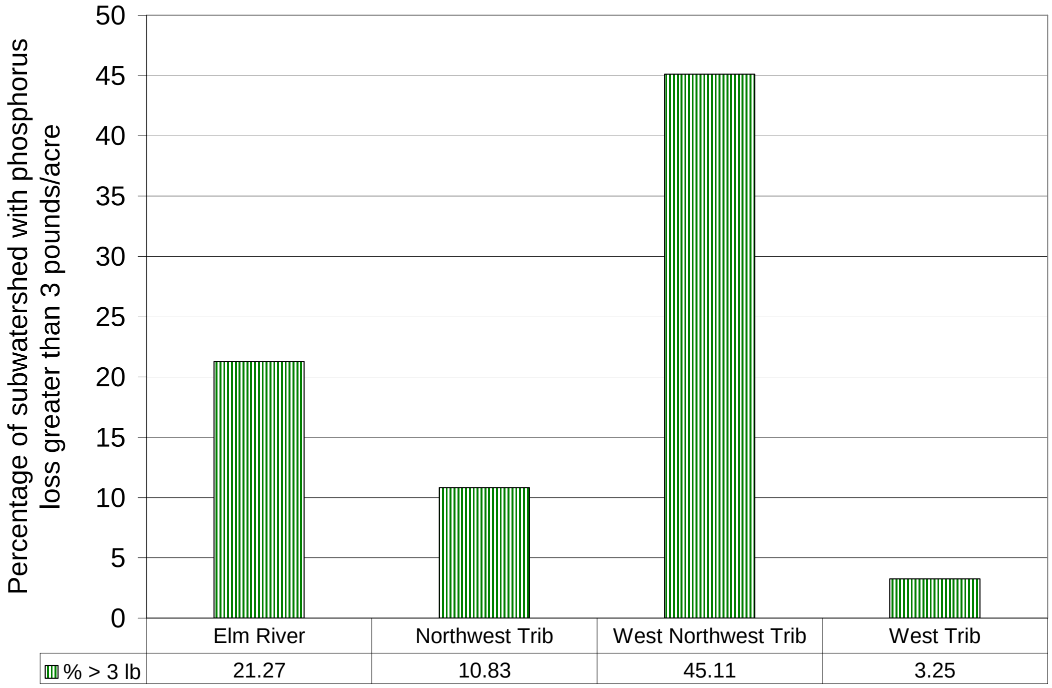


Figure 30. Percentage of Subwatershed with AGNPS Model Predicted Phosphorus Loss in Excess of 3 Pounds Per Acre (Highly Critical).

<u>Animal Feeding Operation Density and Condition</u>

Animal feeding operation (AFO) density and condition was evaluated using the AGNPS model in the Pheasant Lake watershed. The AGNPS model evaluated AFO condition within the subwatersheds through a ranking system based on a scale of zero to 100, where zero represents no increases in the concentration or delivery of chemical oxygen demand, phosphorus or nitrogen in AFO runoff, and 100 represents complete saturation of these analytes.

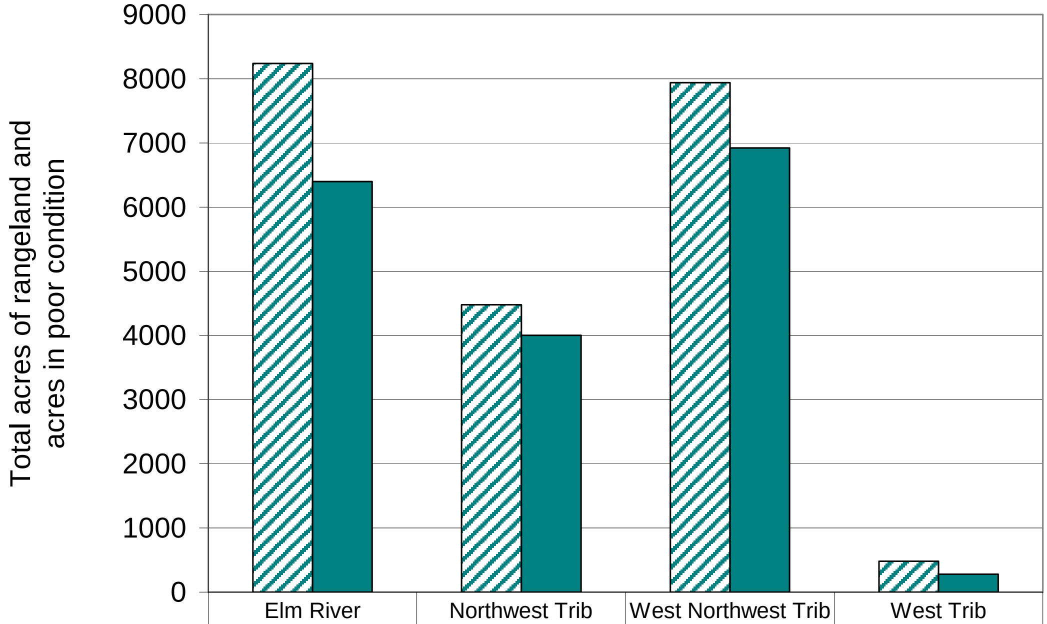
A total of 15 AFOs were identified with a AFO-to-acre ratio of 0.03 for the Elm River, Northwest, and West Northwest subwatersheds and zero for the West subwatershed. Twelve out of fifteen AFOs scored 40 or above and eight had a ranking of 50 or above. Sixty-seven percent of the AFOs in the Elm River subwatershed had a ranking above 50 followed in descending order by the Northwest subwateshed at 60 percent and the West Northwest subwatershed at 25 percent (Table 18).

Table 18. AGNPS Model AFO Scores and AFO Per Acre Density.

Subwatershed	Acres	Number of Feedlots	Score >30	Score >40	Score >50	Percent >50	Feedlot/Acre
Elm River	23,880	6	6	6	4	67	0.03
Northwest	17,360	5	5	5	3	60	0.03
West Northwest	14,720	4	1	1	1	25	0.03
West	4,920	0	0	0	0	0	0

Pasture and Rangeland Condition

A rapid visual assessment protocol was used to rank range and pasture land condition into three categories of poor, fair, and good. The survey identified 21,140 acres of pasture and rangeland in the four subwatersheds, with 83 percent or 17,600 acres ranked in the poor category. Of the four subwatersheds, the West contained the least percentage of acres in poor condition with a 58.3 percent, followed in increasing order by the Elm River at 77.67 percent, the West Northwest at 87.15 percent, and the Northwest at 89.29 percent (Figures 31 and 32).



	Elm River	Northwest Trib	West Northwest Trib	West Trib
Range	8240	4480	7940	480
Poor Range	6400	4000	6920	280

Figure 31. Acres of Rangeland and Rangeland in Poor Condition by Subwatershed.

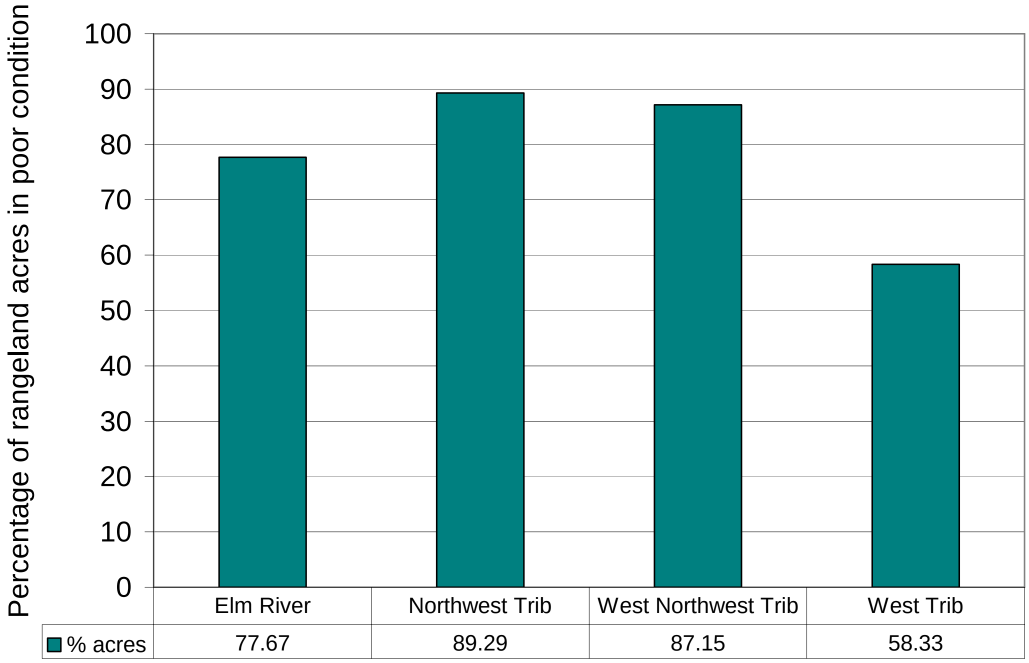


Figure 32. Percentage of Rangeland Acres in Poor Condition by Subwatershed.

5.4 Dissolved Oxygen

Pheasant Lake is listed as fully supporting but threatened for fish and aquatic biota uses because dissolved oxygen levels were observed below the North Dakota water quality standard of "not less than 5.0 mg L^{-1}". For Pheasant Lake, low dissolved oxygen levels appear to be related to excessive nutrient loadings.

The cycling of nutrients in aquatic ecosystems is largely determined by oxidation-reduction (redox) potential and the distribution of dissolved oxygen and oxygen-demanding particles (Dodds, 2002). Dissolved oxygen gas has a strong affinity for electrons, and thus influences biogeochemical cycling and the biological availability of nutrients to primary producers such as algae. High levels of nutrients can lead to eutrophication, which is defined as the undesirable growth of algae and other aquatic plants. In turn, eutrophication can lead to increased biological oxygen demand and oxygen depletion due to the respiration of microbes that decompose the dead algae and other organic material.

AgNPS and BATHTUB models indicate that excessive nutrient loading is responsible for the low dissolved oxygen levels in Pheasant Lake. Wetzel (1983) summarized, "The loading of organic matter to the hypolimnion and sediments of productive eutrophic lakes increases the consumption of dissolved oxygen. As a result, the oxygen content of the hypolimnion is reduced progressively during the period of summer stratification."

Carpenter et al. (1998), has shown that nonpoint sources of phosphorous has lead to eutrophic conditions for many lakes/reservoirs across the U.S. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic plants.

They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment of designated beneficial uses. However, the rates of recovery are variable among lakes/reservoirs. This supports the Department of Health's viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, the concern is that this process takes a significant amount of time (5-15 years).

In Lake Erie, heavy loadings of phosphorous have impacted the lake severely. Monitoring and research from the 1960's has shown that depressed hypolimnetic DO levels were responsible for large fish kills and large mats of decaying algae. Binational programs to reduce nutrients into the lake have resulted in a downward trend of the oxygen depletion rate since monitoring began in the 1970's. The trend of oxygen depletion has lagged behind that of phosphorous reduction, but this was expected (See: http://www.epa.gov/glnpo/lakeerie/dostory.html).

Nürnberg (1995, 1995a, 1996, 1997), developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that AF is positively correlated with average annual total phosphorous (TP) concentrations. The AF may also be used to quantify responses to watershed restoration measures which makes it very useful for TMDL development. Nürnberg (1996), developed several regression models that show nutrients control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. NDDoH has calculated the morphometric parameters such as surface area (A_o = 165.8 acres; 0.6709 km^2), mean depth (z = 7.3 feet; 2.22 meters), and the ratio of mean depth to the surface area ($z/A_o^{0.5}$ = 2.71) for Pheasant Lake which show that these parameters are within the range of lakes used by Nürnberg. Based on this information, NDDoH is confident that Nürnberg's empirical nutrient-oxygen relationship holds true for North Dakota lakes and reservoirs. NDDoH is also confident that prescribed BMPs will reduce external loading of nutrients to Pheasant Lake which will reduce algae blooms and therefore increase oxygen levels to above State standards.

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and EPA's regulations require that "TMDLs should be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety (MOS) can either be incorporated into conservative assumptions used to develop the TMDL (implicit) or added as a separate component of the TMDL (explicit). An explicit margin of safety of 10 percent was used in the Pheasant Lake TMDL. The explicit margin of safety was used based on the absence of point sources in the watershed.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and the EPA's regulations require that a TMDL be established with seasonal variations. Pheasant Lake's TMDL addresses seasonality because the BATHTUB model incorporates seasonal differences in its prediction of annual total phosphorus and nitrogen loadings.

7.0 TMDL

The tables below summarizes the nutrient and dissolved oxygen TMDLs for Pheasant Lake in terms of loading capacity, wasteload allocations, load allocations, and a margin of safety. The TMDL can be generically described by the following equation.

TMDL = LC = WLA + LA + MOS

where

LC loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;

WLA wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;

LA load allocation, or the portion of the TMDL allocated to existing or future non-point sources;

MOS margin of safety, or an accounting of the uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity.

7.1 Nutrient TMDL

7.1.1 Phosphorus TMDL

Based on data collected in 2001 and 2002 the existing load to Pheasant Lake is estimated at 3,880.0 kg. Assuming a 50% reduction based on BATHTUB and AGNPS modeling results in Pheasant Lake reaching a TMDL target total phosphorus concentration of 0.365 mg L^{-1}, then the TMDL or Loading Capacity is 1,940.0 kg. Assuming10% of the (194.0 kg/yr) is assigned to the MOS and there are no point sources in the watershed all of the remaining loading capacity (1746.0 kg/yr) is assigned to the load allocation (Table 19).

The TMDL established for Pheasant Lake is 1940.0 kg/yr total phosphorus load to the lake achieved by a 50% reduction in external annual total phosphorus load. This is a "measured load" which was derived from the BATHTUB model using the flow and concentration data collected during the period of the assessment. The annual loading will vary from year-to-year; therefore, this TMDL is considered a long term average percent reduction in phosphorus loading. The

TMDL contains a linkage analysis between phosphorus loading and low dissolved oxygen in lakes and reservoirs. It is anticipated that meeting the phosphorus load reduction target in Pheasant Lake will address the dissolved oxygen impairment.

Table 19. Summary of the Phosphorus TMDL for Pheasant Lake.

Category	Total Phosphorus (kg/yr)	Explanation
Existing Load	3,880.0	From observed data
Loading Capacity	1,940.0	50 percent total reduction based on BATHTUB
Wasteload Allocation	0	No point sources
Load Allocation	1,746.0	Entire loading capacity minus MOS is allocated to non-point sources
MOS	194.0	10% of the loading capacity (1,940.0kg/yr) is reserved as an explicit margin of safety

7.2 Dissolved Oxygen TMDL

It is expected that by attaining the nutrient load reduction target established for Pheasant Lake will address the dissolved oxygen impairment. A reduction in nutrient load to Pheasant Lake would be expected to lower algal biomass levels in the water column thereby reducing the biological oxygen demand exerted by the decomposition of these primary producers. The reduction in biological oxygen demand is therefore assumed to result in attainment of the dissolved oxygen standard.

8.0 ALLOCATION

A 50 percent nutrient load reduction target was established for the entire Pheasant Lake watershed. This reduction was set based on the BATHTUB model, which predicted that under similar hydraulic conditions, an external nutrient load reduction of 50 percent would change Pheasant Lake's trophic status indicators (chlorophyll-*a* and secchi disk) to a Carlson's Trophic Status Index of 60 or less (Figure 19).

Using the AGNPS model, it was determined that if 70 percent of the critical areas (42,658 acres) in the watershed containing greater than 5 tons of soil loss, 3 pounds or greater nitrogen loss, and 1.5 pounds or greater phosphorus loss during a single rain event of 4 inches in 24 hours were addressed through BMPs, then the sediment load would decrease by 21 percent, total nitrogen by 65 percent, and total phosphorus would decrease by 54 percent. These values are all within the reduction required by the above TMDLs.

The TMDLs in this report are a plan to improve water quality by implementing BMPs through a volunteer, incentive-based approach. This TMDL plan is put forth as a recommendation to what needs to be accomplished for Pheasant Lake and its watershed to meet and protect its beneficial uses. Water quality monitoring should continue to assess the effects of recommendations made in this TMDL. Monitoring may indicate that loading capacity recommendations be adjusted.

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Pheasant Lake and a request for comment was mailed to participating agencies, partners, and to those who request a copy. Those included in the mailing of a hard copy are as follows:

- James River Soil Conservation District
- Dickey County Water Resource Board
- Natural Resource Conservation Service (Dickey County Field Office)
- Environmental Protection Agency
- U.S. Fish & Wildlife Service

In addition to mailing copies of this TMDL for Pheasant Lake to interested parties, the TMDL was posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.health.state.nd.us/wq/. A 30 day public notice soliciting comment and participation was published in the following newspapers:

- Bismarck Tribune; September 1, 2006
- Jamestown Sun; September 1, 2006
- The Dickey County Leader; September 7, 2006

The 30 day public notice was held from September 1 to October 11, 2006 and comments were received from the Environmental Protection Agency Region 8, the Pheasant Lake Neighborhood Association and the Dickey County Water Resource Board. Formal written comments submitted to the NDDoH can be found in Appendix B. Letters of support and the Department's response to all comments received are included in Appendix C and D, respectively.

10.0 MONITORING

To insure that the implementation of BMPs will reduce phosphorus levels and result in a corresponding increase in dissolved oxygen, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan (QAPP).

Specifically, monitoring will be conducted for all variables that are currently causing impairments to the beneficial uses of the waterbody. These include, but are not limited to nutrients (i.e., nitrogen and phosphorus) and dissolved oxygen. Once a watershed restoration plan (e.g. 319 PIP) is implemented, monitoring will be conducted in the lake/reservoir beginning two years after implementation and extending 5 years after the implementation project is complete.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g. USDA EQIP), as well as securing a local project sponsor and the required matching funds. Provided these three requirements are in place, a project implementation plan (PIP) is developed in accordance with the TMDL and submitted to the ND Nonpoint Source Pollution Task Force and US EPA for approval. The implementation of the best management practices contained in the NPS pollution management project is voluntary.

Therefore, success of any TMDL implementation project is ultimately dependent on the ability of the local project sponsor to find cooperating producers.

Monitoring is an important and required component of any PIP. As a part of the PIP, data are collected to monitor and track the effects of BMP implementation as well as to judge overall project success. Quality Assurance Project Plans (QAPPs) detail the strategy of how, when and where monitoring will be conducted to gather the data needed to document the TMDL implementation goal(s). As data are gathered and analyzed, watershed restoration tasks are adapted to place BMPs where they will have the greatest benefit to water quality.

12.0 ENDANGERED SPECIES ACT COMPLIANCE

States are encouraged to participate with the U.S. Fish and Wildlife Service and the U.S. EPA in documenting threatened and endangered species on the Endangered Species List. In an effort to assist in Endangered Species Act compliance, a request for a list of endangered and/or threatened species was made to the U.S. Fish and Wildlife Service (Figure 33 and 34). A hard copy of the draft TMDL report will also be sent to the U.S. Fish and Wildlife Services Bismarck, North Dakota office for review. The following is a list of threatened or endangered species specific to Pheasant Lake and Dickey County.

- Whooping Crane (Grus Americana), Endangered
- Gray wolf (Canis lupus), Endangered
- Bald Eagle (Haliaeetus leucocephalus), Threatened

U.S. Fish & Wildlife Service
3425 Miriam Avenue
Bismarck, North Dakota 58501

OFFICE TRANSMITTAL

To: Michael Hargiss
ND Department of Health - Division of Water Quality
Fargo, ND

☐ Action
■ Information

From: Jeffrey Towner Division: Ecological Services Date: 5-17-06

Attached is a list of the threatened and endangered species for Dickey County. If we can be of any further assistance, please let us know.

Figure 33. Office Transmittal Received from U.S. Fish & Wildlife Service.

FEDERAL THREATENED AND ENDANGERED SPECIES
FOUND IN DICKEY COUNTY
NORTH DAKOTA
May 2006

ENDANGERED SPECIES

Birds

Whooping crane (Grus Americana): Migrates through west and central counties during spring and fall. Prefers to roost on wetlands and stockdams with good visibility. Young adult summered in North Dakota in 1989, 1990, and 1993. Total population 140-150 birds.

Mammals

Gray wolf (Canis lupus): Occasional visitor in North Dakota. Most frequently observed in the Turtle Mountains area.

THREATENED SPECIES

Birds

Bald eagle (Haliaeetus leucocephalus): Migrates spring and fall statewide but primarily along the major river courses. It concentrates along the Missouri River during winter and is known to nest in the floodplain forest.

Figure 34. Threatened and Endangered Species List and Designated Critical Habitat.

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Appendix A
Pheasant Lake Water Quality Assessment with Proposed Pollution Reduction Targets

PHEASANT LAKE

WATER QUALITY ASSESSMENT

With

PROPOSED POLLUTION REDUCTION TARGETS

Dickey County
(HUC 10160004)
Elm River Basin, North Dakota

North Dakota Department of Health
September 2003

PHEASANT LAKE
WATER QUALITY ASSESSMENT
With
PROPOSED POLLUTION REDUCTION TARGETS

Dickey County
Elm River Basin, North Dakota
(8 Digit Hydrologic Unit Code 10160004)

Prepared for the Dickey County Soil Conservation District

By Peter Wax

North Dakota Department of Health, Division of Water Quality, Surface Water Program

State Health Officer
Dr. Terry Dwelle

Division Director
Dennis R. Fewless

Program Manager
Michael J. Ell

September 2003

SUMMARY

1. WATERBODY INFORMATION

State: North Dakota
County: Dickey County

Major River Basin: James River Basin
8-Digit Hydrologic Unit Code: 10160004

Waterbody Name: Pheasant Lake
Location: Dickey County

Waterbody size: 232.1 acres
Watershed Area: 60,880 acres (AGNPS estimated)
Discharges to: Elm River

Designated Uses Impaired:
1) Recreation (Fishing, Swimming)

Constituent(s) of Concern:
1) Phosphorus
2) Nitrogen
3) Sediments
4) Dissolved oxygen

Applicable Water Quality Standard:
Aquatic Life:
The quality of water shall be such to support the propagation of life, both of resident fish species and other aquatic biota.

Nutrients:
The standards for nitrates and phosphorus are interim at
1.0 mg L^{-1} and 0.1 mg L^{-1}, respectively. The standard for dissolved oxygen is 5 mg L^{-1}.

2. WATER QUALITY TARGET DEVELOPMENT

Analysis/Modeling:
Flux Model:
Five locations within the Pheasant Lake watershed were monitored for concentrations of total nitrogen, total ammonia, nitrate + nitrite, total phosphorus and total suspended solids. Manual and automated stage was recorded, and periodic flow measurements were collected for loading estimates. Loading estimates were facilitated utilizing the U.S. Army Corps of Engineers flux model.

Bathtub Model:
Inlake water quality data and stream load were used to calibrate the U.S. Army Corps of Engineers trophic response model " bathtub". Multiple simulations of the calibrated trophic response model were run to identify the amount of reduction in external and internal loads of phosphorus and nitrogen required to improvement Pheasant Lake's trophic condition.

Inlake Water Quality Targets:
(1) Change and maintain Pheasant Lake's trophic status indicators (chlorophyll-a and secchi disk) to a Carlson's Trophic Status Index Score of 60 or less. (2) Maintain a dissolved oxygen concentration of 5 mg L^{-1} or greater throughout the water column from the surface to ½ meter above the bottom for the entire year.

Watershed Targets for Nutrients:
Nutrient load reductions targets are 50 percent of the 2001 loads of total nitrogen, nitrate + nitrite as nitrogen and total phosphorus as phosphate.

Watershed Targets for Total Suspended Solids:
Total suspended solids targets of 35 percent of the 2001 load.

Margin of Safety:
1) Conservative modeling assumption
2) Setting targets during the most critical period
3) Aggressive reduction and improvement targets
4) Continued monitoring to ensure full support of the beneficial uses aquatic life and recreation.

3. SOURCE IDENTIFICATION

Modeling:
All watershed land uses were identified and the potential for pollution runoff modeled using the U.S. Department of Agriculture AGNPS model.

Margins of Safety:
1) Conservative modeling assumption.
2) Setting targets during the most critical period.
3) Aggressive reduction and improvement targets
4) Continued monitoring to ensure full support of the beneficial uses of aquatic life and recreation.

Recommendations:
Implement an agricultural nonpoint source pollution abatement project.

Acknowledgments

Numerous scientists, chemists and technicians have made contributions to the Pheasant Lake Assessment. Special thanks goes to Amanda Rall and Chris Nannenga for providing water quality and land use data collection, AGNPS modeling and last minute clarification. Appreciation goes to the staff of the North Dakota Department of Health Division of Chemistry for their accurate and timely analysis of water quality and bacteria samples. Lastly, thank you Loreeta L. Frank and Melissa Miller for editing and providing guidance on the completion of this document.

Funding for this project was provided through a U.S. Environmental Protection Agency, Section 303 (d) Total Maximum Daily Load Grant.

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1.0 EXECUTIVE SUMMARY

Pheasant Lake is located on the Elm River in southeastern North Dakota (Figure 1). Pheasant Lake discharges to the Elm River just prior to entering South Dakota. Outlet flows travel in a southern direction to Elm Lake in South Dakota, then in an easterly direction to Elm River's confluence with the James River near Columbia, South Dakota.

Pheasant Lake is a narrow 232-acre impoundment with a maximum depth of approximately 15 feet and a mean depth of 7.4 feet (Figure 2). The dam was built in 1963 and belongs to the Dickey County Water Management Board. The dam forms the road bed for North Dakota Highway 11 approximately eight miles east of the town of Ellendale. Currently, Pheasant Lake is managed by the North Dakota Game and Fish Department (NDG&F) as a warm water fishery.

In 2000, Dickey County Soil Conservation District approached the North Dakota Department of Health (NDDoH) for help in addressing the declining water quality of Pheasant Lake. The discussions resulted in the implementation of a lake and watershed assessment project with the goal of identifying the effects of stored and contributing pollutants on Pheasant Lake and, to the extent possible, the sources of pollutants.

The project began in the spring of 2001 and continued through the winter of 2001-2002. The assessment project addressed all pollutants of concern within the lake and watershed identified by the NDDoH. The NDDoH assesses its waterbodies for compliance with the water quality criteria established for the beneficial uses as required by the Federal Clean Water Act (CWA). This assessment is commonly called the TMDL or 303(d) list.

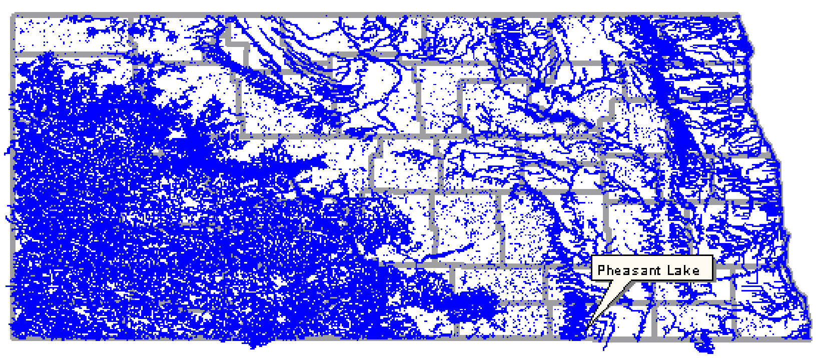


Figure 1. Location of Pheasant Lake

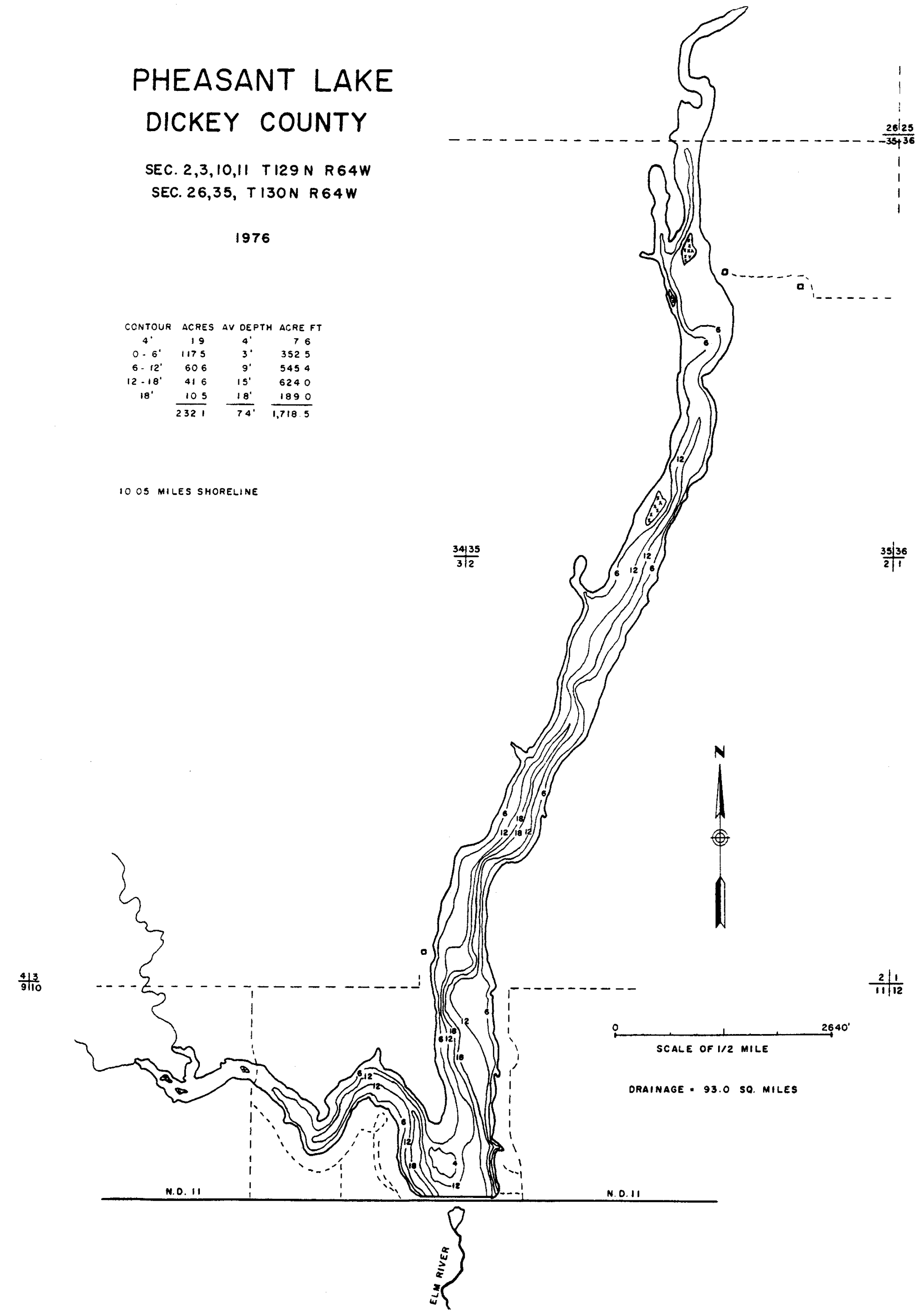


Figure 2. Morphometric map of Pheasant Lake

Pheasant Lake is listed in the 1998 303(d) list for impairment of the recreational use (sport fishing and aesthetics) due to nutrients. The data collected in 2001-2002 identified an additional recreational-use impairment (sport fishing) due to low dissolved oxygen concentrations.

Currently, Pheasant Lake is highly eutrophic and experiences periodic algal blooms and resulting reductions in dissolved oxygen concentrations. The state's interim standards for total phosphorus and nitrates is 0.10 mg L^{-1} and 1.0 mg L^{-1}, respectively. The targets for these nutrients identified by the assessment project are 0.170 mg L^{-1} for phosphorus and 1.0 mg L^{-1} for nitrate + nitrite as nitrogen.

The state standard for dissolved oxygen of 5.0 mg L^{-1} is founded on the minimum concentration required to support a year-round fishery. The dissolved oxygen target for Pheasant Lake is set at the State standard of 5.0 mg L^{-1}.

The Pheasant Lake Water Quality Assessment Project (assessment) collected water quality and quantity data on five stream sites and three in-lake sites; land use, slope, soil type and cropping practice; conservation practice; and associated information needed for the U.S. Department of Agriculture AGNPS model on the entire watershed. The water quality data was collected to develop a calibrated trophic response model for Pheasant Lake, to identify the pollutants of concern, and to establish the amount of pollution control needed to improve Pheasant Lake's trophic condition based on meeting the requirements of fully supporting the beneficial uses of recreation. The land-use data and subsequent AGNPS modeling was used to identify sources of concern and the amount of change likely to be achieved through implementation of agricultural best management practices (BMPs).

Nutrient-load reduction targets for the entire watershed are a minimum of 50 percent of the 2001 loads of total nitrogen, nitrate + nitrite as nitrogen and total phosphorus as phosphate based on the calibrated bathtub trophic response model for Pheasant Lake. The selection of a 50 percent reduction is two-fold: (1) the bathtub model predicted that under similar hydraulic conditions, an external nutrient-load reduction of 50 percent would change Pheasant Lake's trophic status indicators chlorophyll-a and secchi disk to a Carlson's Trophic Status Index Score of 60 or less (Table 1); and (2) a 50 percent reduction in external load is probably the upper limit of effect a voluntary nonpoint source pollution project could aspire to achieve.

Discrete subwatershed targets for total nitrogen, nitrates, total phosphorus and total suspended solids were developed using the relationship between the percentage of subwatershed critical area for soil and nutrient runoff and the measured mass load of soil and appropriate nutrient (Table 2). The targets were developed by mathematically defining the relationship between the AGNPS model-predicted percentage of critical area for soil erosion, and nitrogen and phosphorus delivery to the measured mass load of total suspended solids, total nitrogen, nitrates and total phosphorus. Then, with the exception of total suspended solids, the percentage of critical area in the equation was reduced incrementally until a combined subwatershed reduction in load between 55 and 60 percent was obtained. A discrete flow-weighted concentration (flux/flow) was then calculated for each subwatershed (Tables 3 through 6).

Critical areas are defined for soil loss as those acres with a AGNPS model-predicted soil loss of 5 tons or greater and for nitrogen as those acres with a nitrogen loss of 3 pounds or greater, and for phosphorus as those acres with a phosphorus loss of 1.5 pounds or greater during a single rain event of 4 inches in 24 hours (Section 5.5). In total, the percentage of critical area needed to be reduced by 70 percent for soil and phosphorus loss and 65 percent for nitrogen loss to achieve an estimated reduction in total suspended solids of 21 percent, total nitrogen of 60 percent, nitrate + nitrite of 55 percent, and total phosphorus of 54 percent.

Table 1. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external loads of total phosphorus and total nitrogen

	Value	
Variable	Observed	Model - 50 % Reduction
Total Phosphorus (mg L^{-1})	0.545	0.276
Total Nitrogen (mg L^{-1})	1.468	0.786
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.052
Chlorophyll-a (Fg L^{-1})	19.250	17.180
Secchi disk depth (m)	0.960	1.710
Carlson's TSI Phosphorus	95.010	85.200
Carlson's TSI Chlorophyll-a	59.610	58.500
Carlson's TSI Secchi	60.590	52.250

For total suspended solids, a reduction in the percentage of critical areas per subwatershed of 70 percent was selected, even though this netted a reduction in load of only 35 percent. Seventy percent was selected for two reasons: first, total suspended solids were not identified as a significant pollutant contribution to Pheasant Lake; and second, a 70 percent reduction in critical areas of soil erosion would match the percentage of reduction targeted for phosphorus, a pollutant closely related to total suspended solids.

The primary strength of this type of target development is that it recognizes the individual physical characteristics of the subwatersheds, such as slope and soil type. Its primary weakness is that it assumes all land managers are currently using management practices that are equal in controlling nonpoint source pollution, lumping both the poor performers and good land stewards together. A secondary weakness is that the mathematical relationship is not perfect. In subwatersheds with only a small percentage of critical area, there is the possibility that the target load could exceed the base load condition as actually occurs in the northwest subwatershed for total suspended solids and the west subwatershed for total phosphorus (Tables 3 and 5).

Table 2.Mathematical relationship between AGNPS model and mass loading analysis for the Pheasant Lake Watershed in 2001

Total Suspended Solids Load = 167.79×(M) + 7850.3

Where (M) is the AGNPS model predicted percent of subwatershed with 5 tons per acre or greater soil loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.5142

Total Nitrogen = 69.796×(M) + 254.88

Where (M) is the AGNPS model predicted percent of subwatershed with 3 pounds per acre or greater nitrogen loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.8381

Nitrate + Nitrite = 17.339×(M) + 156.02

Where (M) is the AGNPS model predicted percent of subwatershed with 3 pounds per acre or greater nitrogen loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.7818

Total Phosphorus = 20.895×(M) + 101.12

Where (M) is the AGNPS model predicted percent of sub-watershed with 1.5 pounds per acre or greater phosphorus loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.6239

Table 3. Total suspended solids reduction targets based on a 70 percent reduction in the amount of critical acres per subwatershed

	Total Suspended Solids	
Tributary	2001 Concentration	Target Concentration
Elm River	5.174	3.9
Northwest	5.394	4.1
West Northwest	4.879	2.6
West	22.642	18.0

	Total Suspended Solids	
Tributary	2001 Mass Load	Target Mass Load
Elm River	11,415	8,575
Northwest	8,332	8,883
West Northwest	15,049	9,711
West	10,165	8,300

Table 3. Continued

	Percent Critical Area for Soil Loss	
Watershed	2001 Percentage	Target Percentage
Elm River	14.41	4.32
Northwest	20.51	6.15
West Northwest	36.96	11.09
West	8.94	2.68

The annual total suspended solids mass load is in kilograms and the flow-weighted concentrations in mg L^{-1}. Percentage of critical acres for soil loss are defined as the number of acres with an AGNPS model-predicted soil loss of 5/tons or greater divided by the number of acres per subwatershed.

Table 4. Total nitrogen targets based on a 60 percent reduction in the critical acres per subwatershed

	Total Nitrogen	
Tributary	2001 Concentration	Target Concentration
Elm River	2.069	0.620
Northwest	1.991	1.043
West Northwest	1.787	0.715
West	2.156	1.408

	Total Nitrogen	
Tributary	2001 Mass Load	Target Mass Load
Elm River	4,565	1,368
Northwest	3,076	1,465
West Northwest	5,513	2,207
West	968	632

	Percent Critical Area for Soil Loss	
Watershed	2001 Percentage	Target Percentage
Elm River	45.56	15.95
Northwest	49.54	17.34
West Northwest	79.89	27.96
West	15.45	4.15

Annual total nitrogen mass load is in kilograms, and flow-weighted concentrations are in mg L^{-1}. The percentage of critical acres for nitrogen loss are defined as the number of acres with an AGNPS model-predicted nitrogen loss of 3 pounds/acre or greater.

Table 5. Nitrate + nitrite as nitrogen targets based on a 60 percent reduction on critical acres per subwatershed

	Nitrate + Nitrite	
Tributary	2001 Concentration	Target Concentration
Elm River	0.554	0.196
Northwest	0.456	0.296
West Northwest	0.511	0.208
West	0.940	0.557

	Nitrate + Nitrite	
Tributary	2001 Mass Load	Target Mass Load
Elm River	1,224	433
Northwest	704	457
West Northwest	1,575	641
West	422	250

	Percent Critical Area for Soil Loss	
Watershed	2001 Percentage	Target Percentage
Elm River	45.56	15.95
Northwest	49.54	17.34
West Northwest	79.89	27.96
West	15.45	5.41

Annual nitrate + nitrate as nitrogen mass load are in kilograms and flow-weighted concentrations in mg L^{-1}. Percentage of critical acres for nitrates are defined as the number of acres with an AGNPS model-predicted nitrogen loss of 3 pounds/acre or greater divided by the total number of acres per subwatershed.

Table 6. Total phosphorus targets based on a 70 percent reduction in the amount of critical acres per subwatershed

	Total Phosphorus	
Tributary	2001 Concentration	Target Concentration
Elm River	0.439	0.124
Northwest	0.387	0.212
West Northwest	0.338	0.169
West	0.372	0.419

	Total Phosphorus	
Tributary	2001 Mass Load	Target Mass Load
Elm River	1,573	444
Northwest	704	386
West Northwest	1,043	522
West	167	188

Table 6. Continued

	Percent Critical Area for Soil Loss	
Watershed	2001 Percentage	Target Percentage
Elm River	54.77	16.43
Northwest	45.39	13.62
West Northwest	67.12	20.14
West	13.82	4.15

Annual phosphorus as phosphate mass load is in kilograms and flow-weighted concentrations are in mg L^{-1}. The percentage of critical acres for phosphorus loss are defined as the number of acres with an AGNP model-predicted phosphorus loss of 1.5 pounds/acre or greater divided by the total number of acres per subwatershed.

As with everything, there is a measure of uncertainty in the interpretations and predictions made in this assessment. It is important to recognize that the science of this assessment does not define the entire dynamics of Pheasant Lake and the contributing watershed. In order to assign some measure of safety to the loading interpretations, lake trophic response predictions and the watershed response to improved land use, both implicit and explicit safety measures were employed.

The first safety measure was implicit and involved the collection of as much data as possible, with monitoring increased during the periods likely to have elevated pollutant loading. This minimized the risk of underestimating load. Secondly, to ensure the most accurate loading estimations as possible with the data available, six different model options were explored, and the one least likely to bias the results with the smallest coefficient variance and flux variance was selected.

Explicit measures included: (1) selecting a greater reduction in lake trophic response than needed to meet the defined goals, and (2) selecting watershed load reduction 5 to 10 percent greater then the minimum required (based on the model results) and basing the response on addressing more land mass then is pragmatically possible.

The final measure of safety is recognizing that beyond all modeling results, calculated targets and best professional judgements, the project will not be considered a success until Pheasant Lake has responded in the manner described in the goals of the project. To define and ensure this occurrence will entail continued monitoring and refinement of the hydraulic rating curves and lake trophic response model.

2.0 STREAM WATER QUALITY AND QUANTITY MONITORING RESULTS

2.1 Overview

Five water quality monitoring stations were established on the Pheasant Lake watershed: Four upstream of Pheasant Lake and one at the lake outlet. Each of the upstream sites were located as near the reservoir as possible on the four largest tributaries to Pheasant Lake (Figure 3). Each site contained a staff gauge, eventually an automated stage recorder and was identified with a verbal description and STORET identification number.

Water quality parameters sampled at each site included total nitrogen as nitrogen, total ammonia as nitrogen, nitrate + nitrite as nitrogen, total kjeldahl nitrogen, total phosphorus as phosphate and total suspended solids. Water quality samplers were collected using depth-width integrated methods, and either by wading during low flows or by suspending a suspended sediment sampler from a bridge or road crossing during high flows.

The water quality sampling regimen was weighted towards higher flows. In general the regimen was designed to mimic the annual hydrologic pattern with two samples per week for the first six weeks after ice-out, one sample per week for the next four weeks, one sample every two weeks for the following four weeks, and one sample monthly through October 31.

In addition, samples were collected during or immediately following any precipitation event large enough to cause a 0.1 foot or greater increase in the stage. Two samples were collected per event in an effort to bracket the rise and fall of the hydraulic rise. If the event occurred when the standard regimen would bracket the event, no additional samples were collected. A complete monitoring plan is contained in Appendix A.

Stage was manually recorded daily until the automated stage recorders were installed. The automated stage recorders measured stage every hour. Hydraulic discharge was measured using a bucket wheel type flow meter and U.S. Geological Survey methods three times during the project period. The flow measurements were combined with stage to calculate a hydraulic discharge rating curve. The rating curve was combined with the manual and automated stage records to calculate an estimated daily discharge. The daily hydraulic discharge calculations were combined with the water quality results and entered into the U.S. Army Corps of Engineers flux model for loading interpretations. Each parameter was run independently through all stratification options and the output with the least potential for bias and the smallest flux variance was selected for loading estimations. Flux output files are contained in Appendix B.

Nutrient and sediment interpretations were restricted to the open-water period from ice-out to October 31. Since the contributing streams are intermittent, this included the entire period of inlet flows and an estimated 96 percent of the outlet flows for the entire hydrologic year.

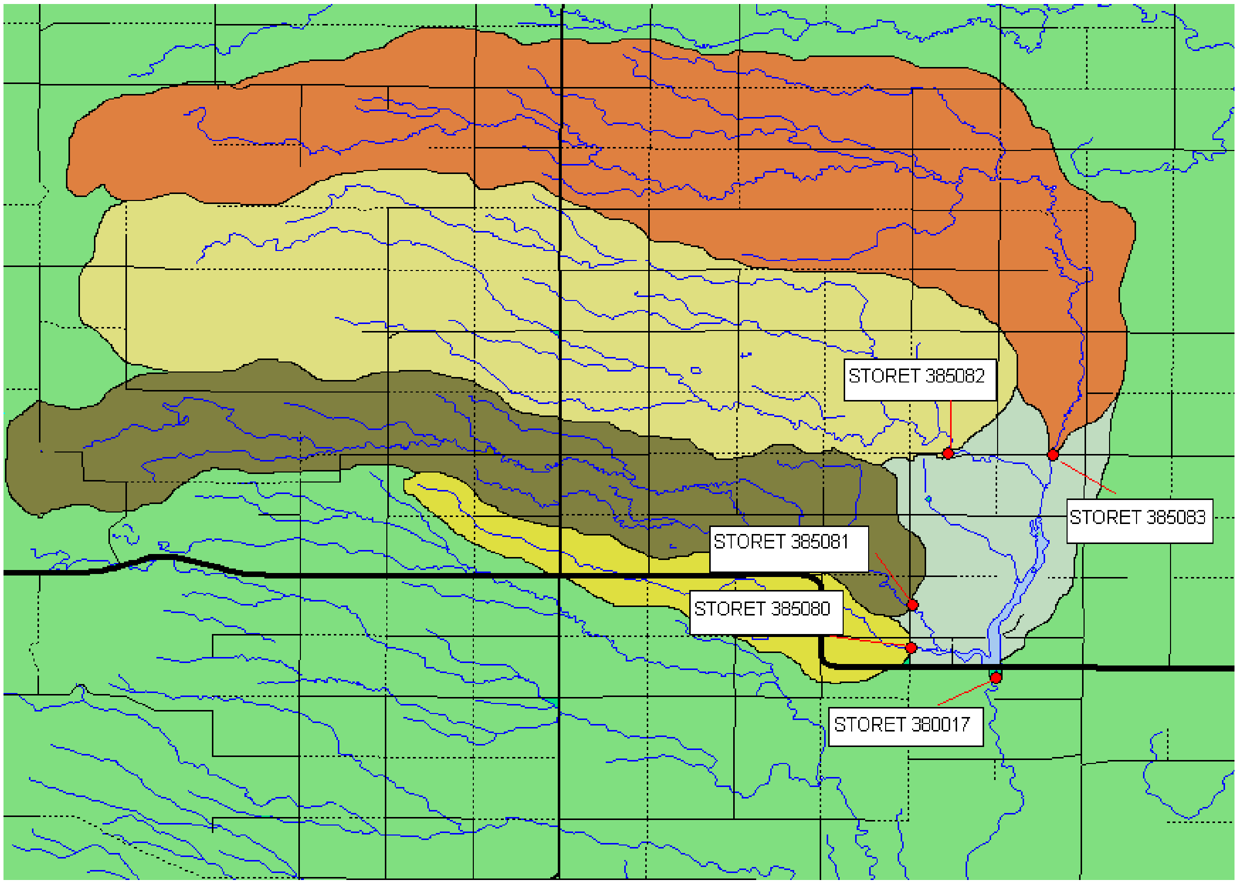


Figure 3. Pheasant Lake watershed and water quality and quantity monitoring stations

2.2 Sampling Duration and Number of Water Quality Samples

The sampling regimen was very aggressive, and the number of samples collected was a product of the lack or presence of flow. The longest running tributary, other than the outlet, opened on March 20 and stopped flowing by July. In that time period 89 water quality samples were collected from the contributing watershed and 31 were collected at the outlet. The breakdown per monitoring station is:

385083 Elm River (28 samples)
385082 Northwest Tributary (25 samples)
385081 West Northwest Tributary (19 samples)
385080 West Tributary (17 samples)
380017 Pheasant Lake Outlet (31 samples)

A complete set of water quality results is contained in Appendix B.

2.3 Hydraulic Discharge Development

Discharge was estimated for all five stream water quality monitoring stations in the Pheasant Lake watershed. All five monitoring stations have relatively few discharge measurements for rating cure development. However, for all but the Elm River station (385083), the measurements were collected over the full range of flows (Figures 4 through 8).

Due to a lack of discharge measurements during high flows at the Elm River station, its rating curve needed to have the highest flows estimated based on its relationship to flow conditions at the Northwest and West Northwest Tributary stations. The seasonal hydraulic discharge (3-20-2001 through 10-31-01) for the five stations balance well, indicating that the discharge errors are acceptable for assessment purposes (Table 7).

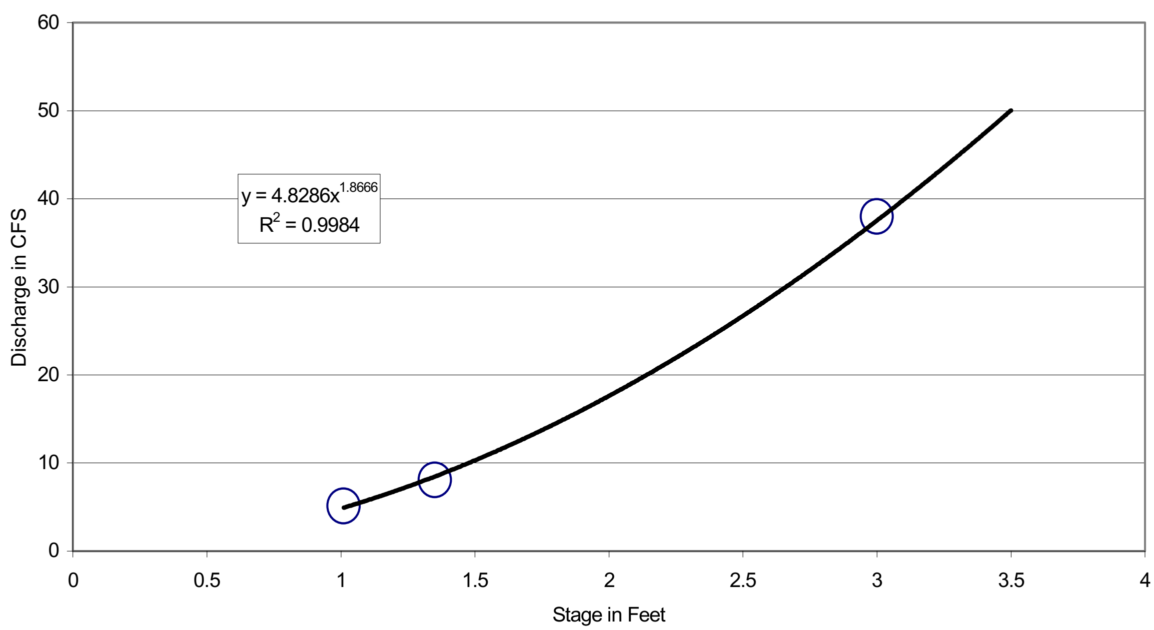


Figure 4. Elm River (385083) rating curve

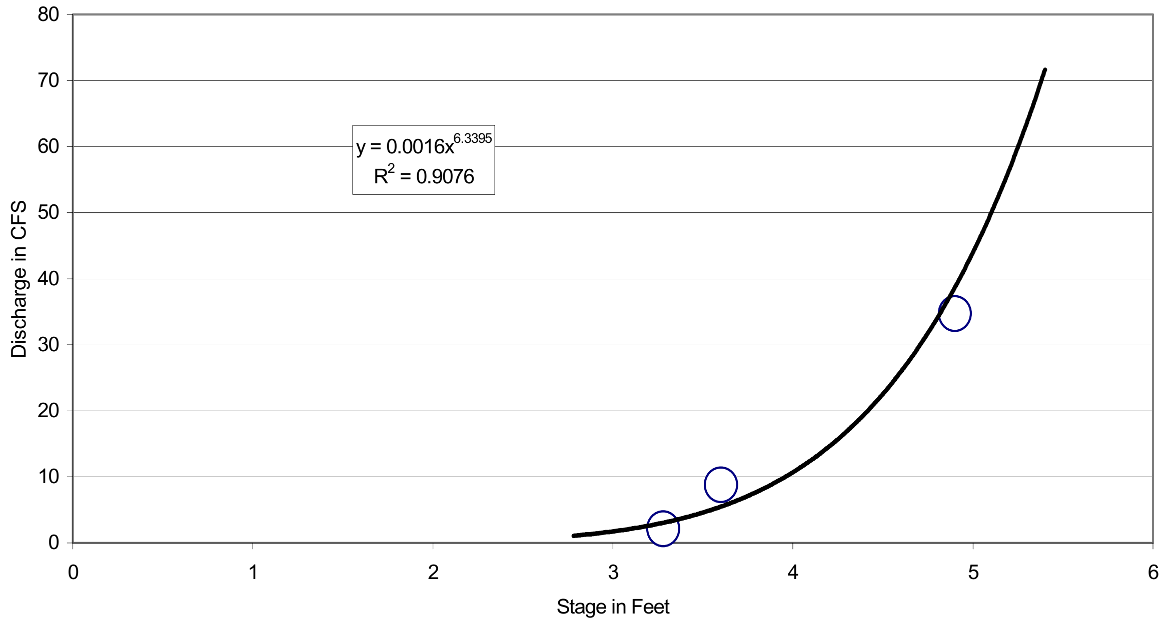


Figure 5. Northwest Tributary (385082) rating curve

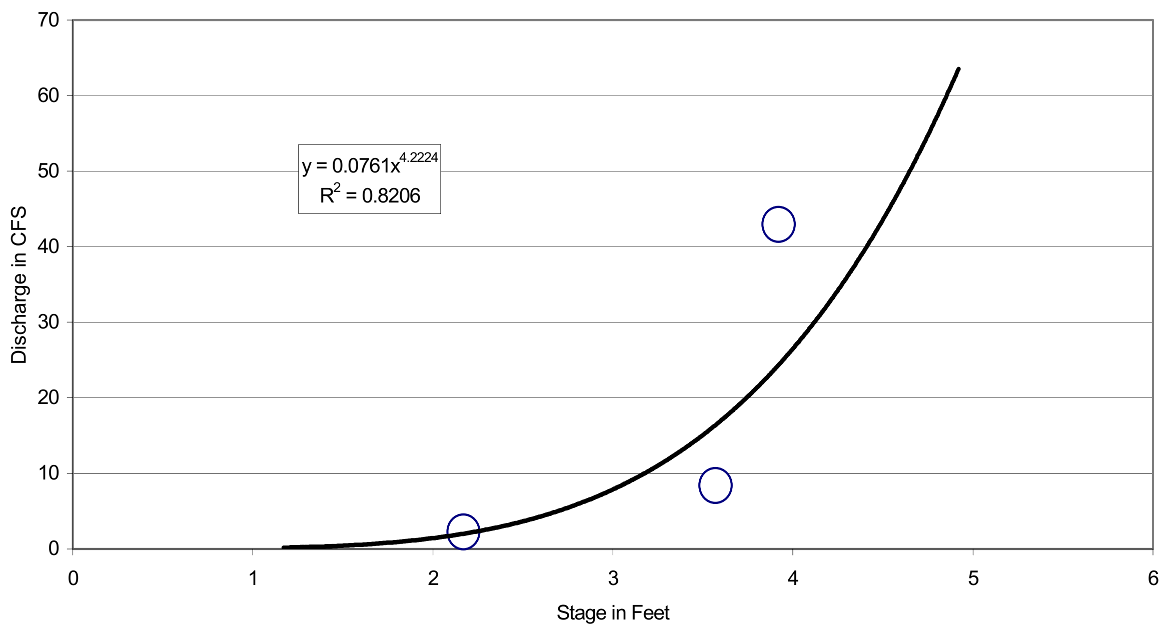


Figure 6. West Northwest Tributary (385081) rating curve

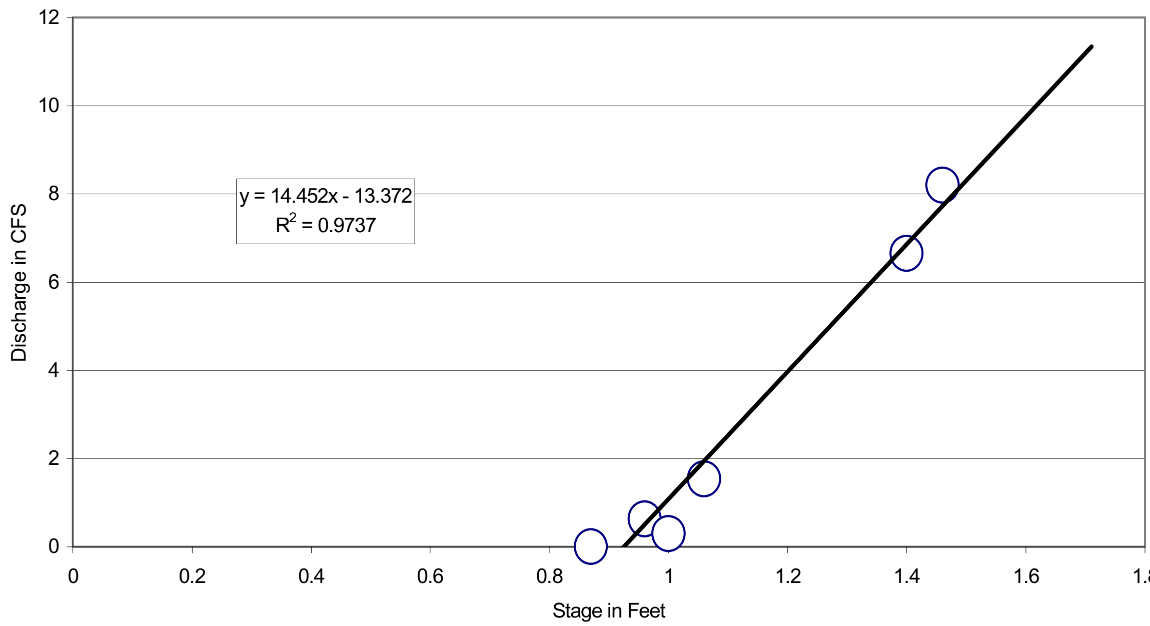


Figure 7. West Tributary (385080) rating curve

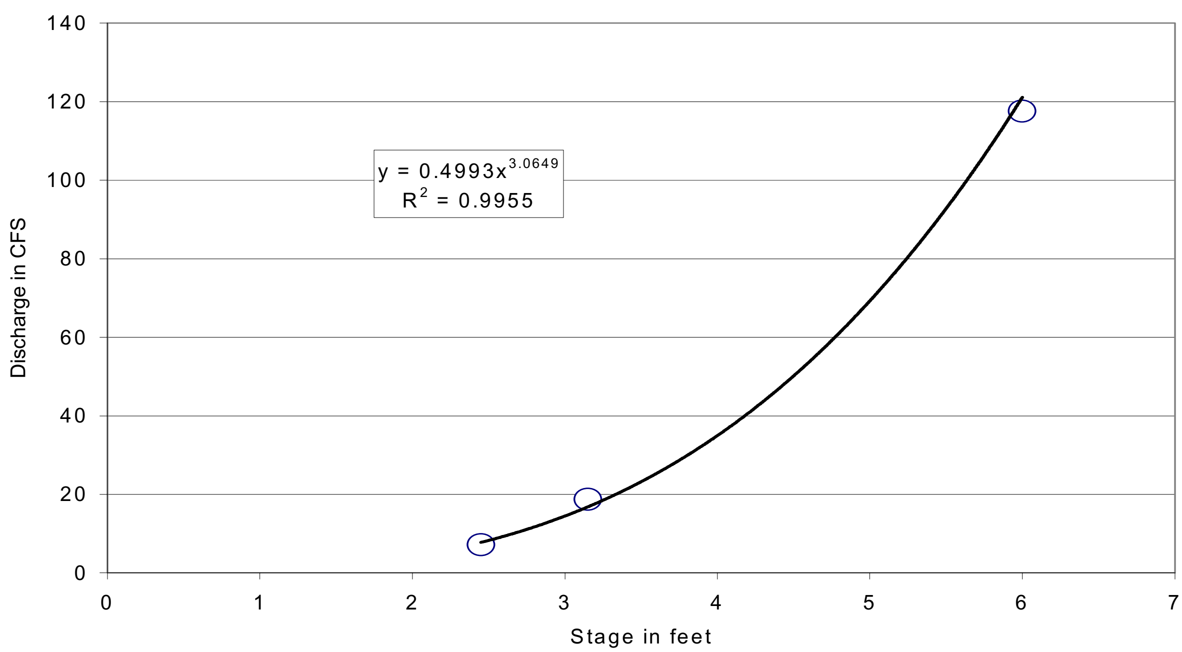


Figure 8. Pheasant Lake Outlet (380017) rating curve

Table 7. Hydraulic balance for the Pheasant Lake Watershed (3-20-01 through 10-31-01)

Station	Acres	Millions of Gallons	Hectare Meter[3]
Precipitation	232	248.1	0.939
Elm River	23,880	583.9	2.210
Northwest Tributary	17,360	406.9	1.540
West Northwest Tributary	14,720	813.7	3.080
West Tributary	4,920	192.6	0.729
Total	61,112	2,245.2	8.498
Evaporation		-352.4	-1.334
Outlet		-1,725.2	-6.530
Ungauged Outflow		167.6	0.634

2.4 Nutrients and Total Suspended Solids Loading and Concentration Analysis

Loading and flow-weighted concentration estimates were facilitated using the U.S. Army Corps of Engineers flux model. The flux model is an interactive program for estimating loading and discharge (Walker, 1987).

The flux model used the daily discharge estimates and the nutrient and total suspended sample results to calculate an estimated daily and seasonal load (March 20 through October 31, 2001) and flow-weighted concentration (flux/flow) for each discrete parameter at all five of the water quality monitoring stations.

The flux model has robust analytical capabilities including six calculation methods and an option to stratify the samples into groups based on flow to reduce bias and increase accuracy. All flux model options were explored to achieve the most accurate daily and seasonal loading estimates for each discrete parameter per station. Accuracy was determined by running all stratification options until the lowest flux variance determined to provide the least bias was achieved (Tables 8 and 9). Complete flux output files are contained in Appendix B.

Table 8. Mass load of nutrients and total suspended solids for the Pheasant Lake watersheds (3-20-01 through 10-30-01)

Station	Nitrate + Nitrite	Total Nitrogen	Total Phosphorus	Suspended Solids
Elm River (385083)	1,224	4,565	1,573	11,415
Northwest Tributary (385082)	704	3,076	597	8,332
West Northwest Tributary (385081)	1,576	5,513	1,043	15,049
West Tributary (385080)	422	968	167	10,165
Outlet (380017)	6,750	26,743	6,369	71,756

Concentrations in kilograms

Table 9. Flow-weighted concentrations of nutrients and total suspended solids for the Pheasant Lake watersheds (3-20-01 through 10-30-01)

Station	Nitrate + Nitrite	Total Nitrogen	Total Phosphorus	Suspended Solids
Elm River (385083)	0.554	2.069	0.439	5.174
Northwest Trib (385082)	0.456	1.991	0.387	5.394
West Northwest Trib (385081)	0.511	1.787	0.338	4.879
West Tributary (385080)	0.940	2.156	0.372	22.642
Outlet (380017)	0.468	1.856	0.442	11.425

Concentrations in mg L^{-1}

2.5 Relationship Between Increases in Hydraulic Discharge, and Nutrient and Total Suspended Solid Concentrations

The relationship between increases in hydraulic discharge in nutrient and suspended solids concentrations was explored in an attempt to develop a correlation, based on discharge and concentration, for pollution reduction target development. Unfortunately, none of the tributaries expressed a clear relationship between hydraulic discharge and nitrates, total nitrogen, total phosphorus or total suspended solids. While the relationships were too weak to develop a reliable correlation, they did identify which tributaries were receiving significant pollution inputs from discrete precipitation events.

In general, the Elm River, Northwest and West Tributaries had recognizable relationships between hydraulic discharge and some species of nitrogen and total phosphorus as phosphate, or both while the West Northwest Tributary and Outlet had no significant relationship to any pollutants monitored (Table 10). These relationships, while not readily explained through simple linear statistics, are visually recognizable when concentrations are graphed temporally along with flow (Figures 9 through 28). However, even these relationships appear to end on or near May 6. Of note, a data set stratified by dates prior to May 6 were dissected out and correlated to discharge with even weaker results.

Table 10. R-Squared values for hydraulic discharge correlated to nutrients and total suspended solids

Station	Nitrate + Nitrite	Total Nitrogen	Total Phosphorus	Suspended Solids
Elm River (385083)	0.4930	0.0648	0.4346	0.0200
Northwest Tributary (385082)	0.1440	0.0043	0.4689	0.0108
West Northwest Tributary (385081)	0.0550	0.0008	0.0006	0.0940
West Tributary (385080)	0.5513	0.4875	0.1698	0.1233
Outlet (380017)	0.3023	0.2369	0.0002	0.0180

2.6 Timing of Nutrient and Sediment Delivery

The timing of increases in nutrient and total suspended solid concentrations are inverse. In general, nutrient concentrations increased early on the rising side of the spring hydrograph, declined just prior to the peak hydraulic discharge, then remained fairly constant or rose slightly. Inversely, total suspended solid concentrations were near or at the detection level during the spring runoff, then increased as the streams receded to or below base flow (Figures 9 through 28). It is hypothesized that the secondary rise in total nitrogen as nitrogen, total phosphorus as phosphate and total suspended solids is a product of internal productivity of the streams themselves and Pheasant Lake in the case of the outlet.

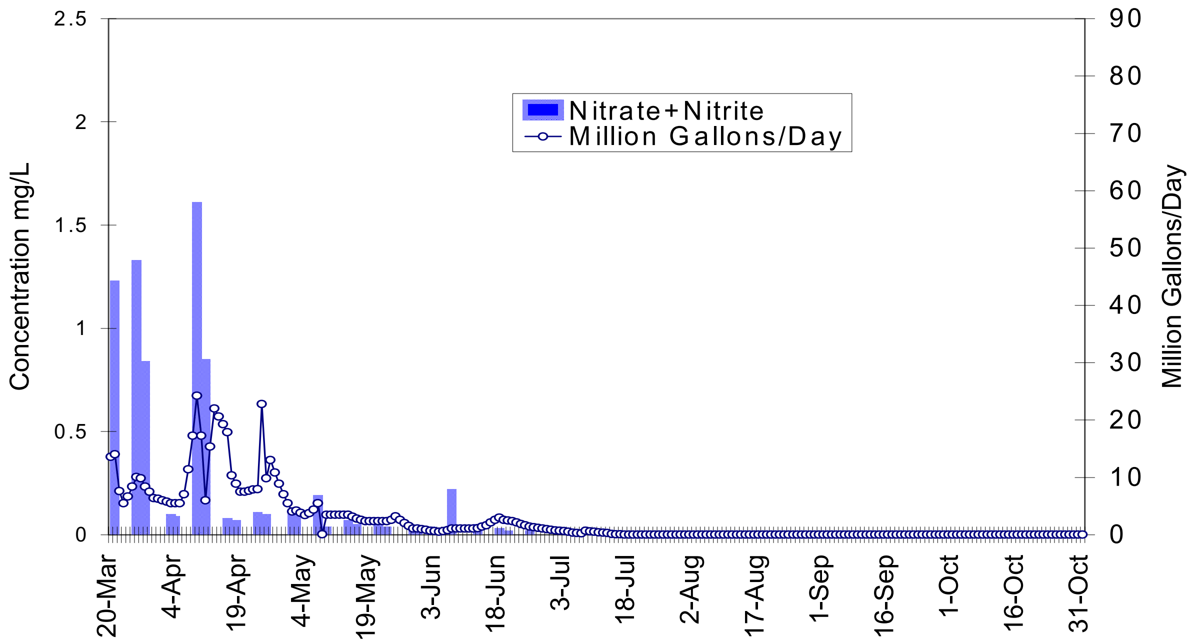


Figure 9. Elm River (385083) temporal distribution of nitrate + nitrite as nitrogen concentrations and hydraulic discharge

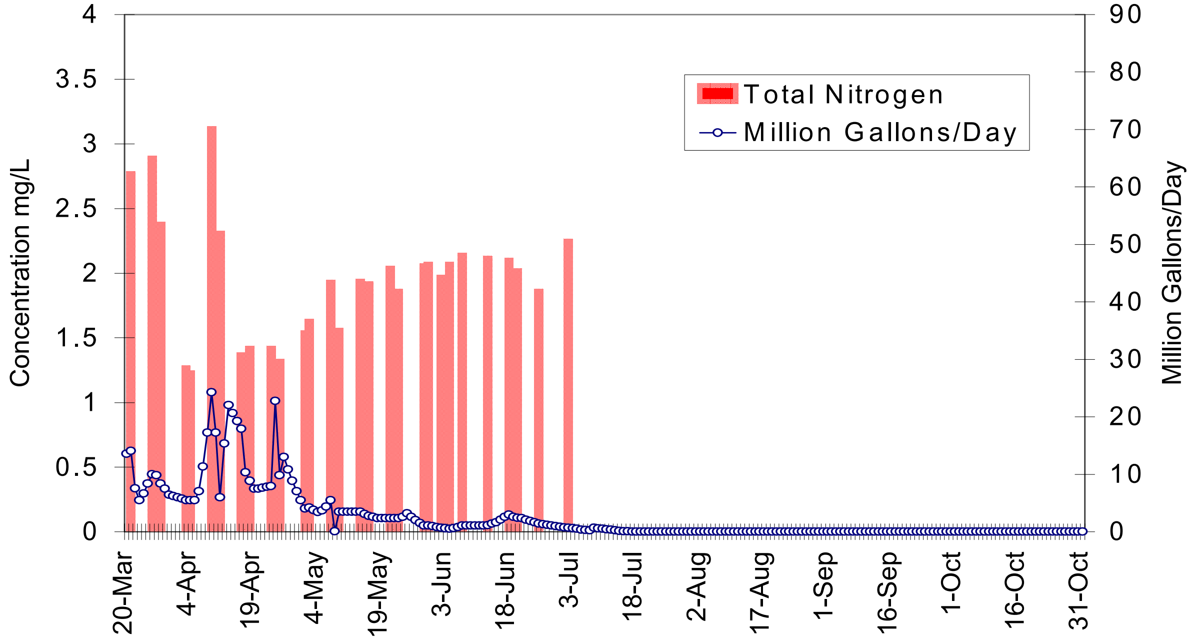


Figure 10. Elm River (385083) temporal distribution of total nitrogen concentrations and hydraulic discharge

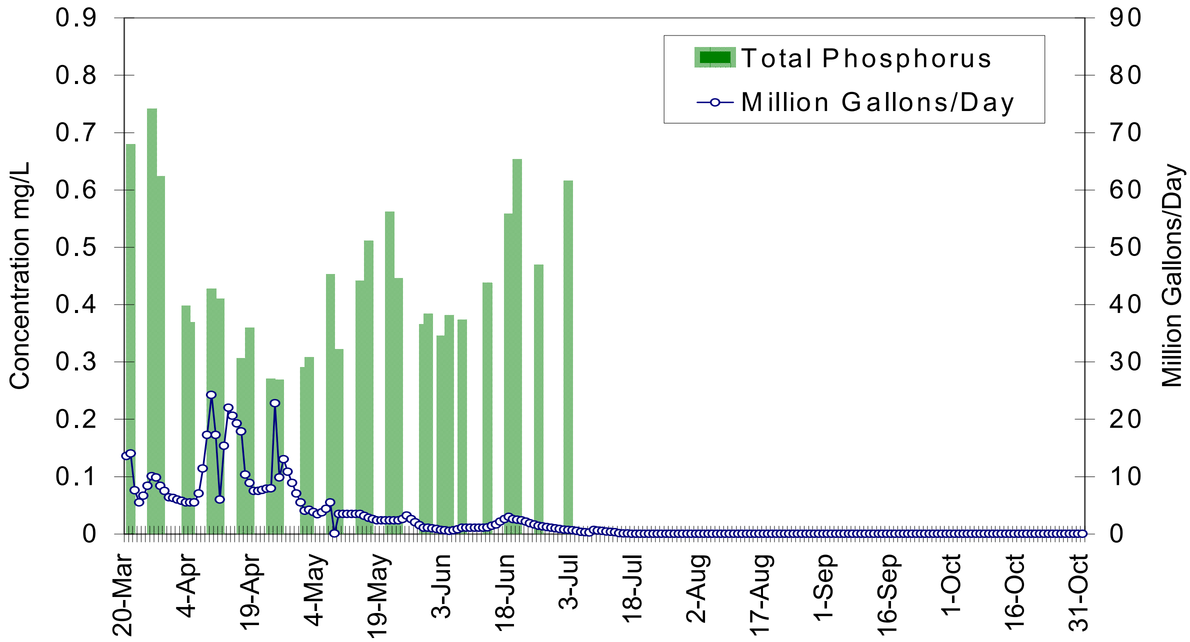


Figure 11. Elm River (385083) temporal distribution of total phosphorus concentrations and hydraulic discharge

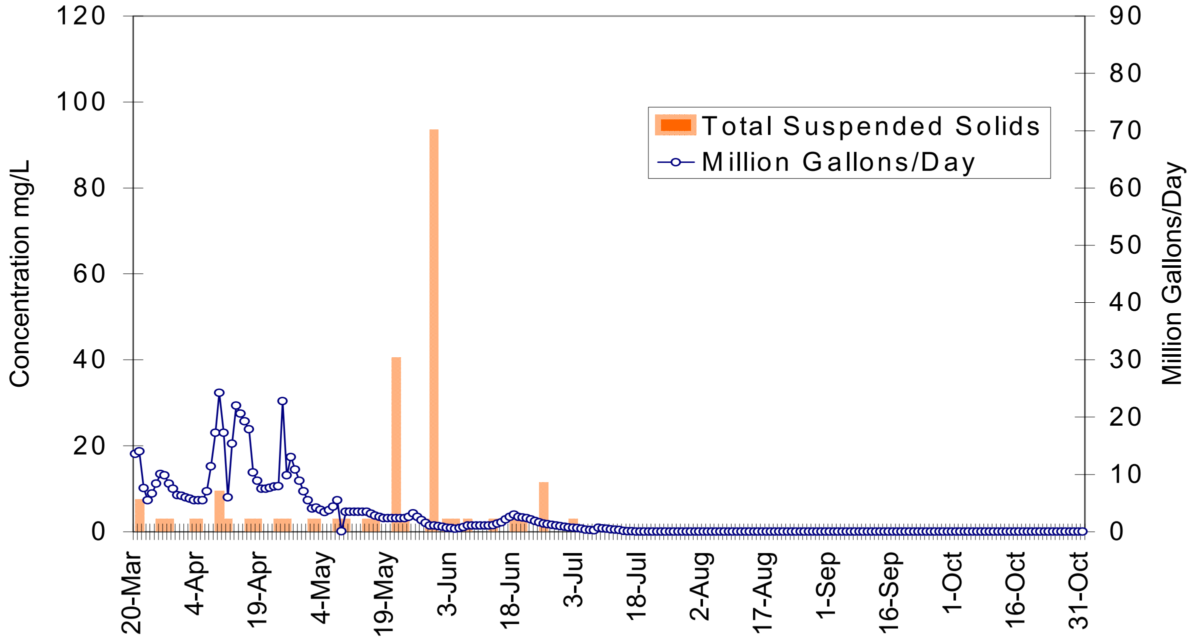


Figure 12. Elm River (385083) temporal distribution of total suspended solids concentrations and hydraulic discharge

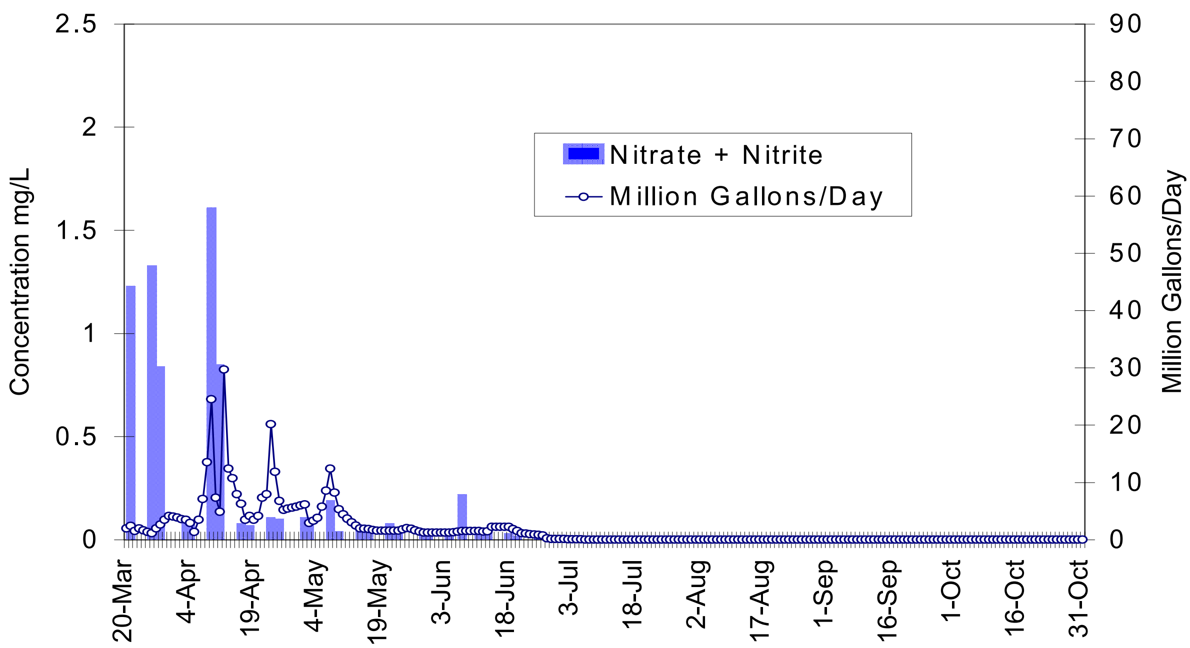


Figure 13. Northwest Tributary (385082) temporal distribution of nitrate + nitrite as nitrogen concentrations and hydraulic discharge

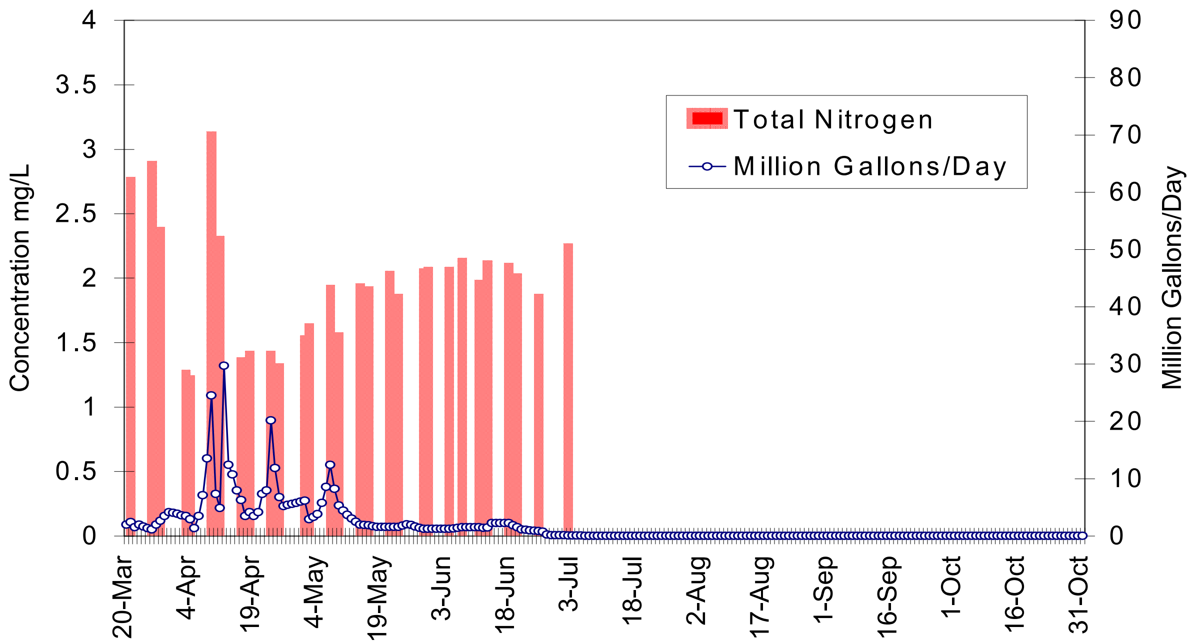


Figure 14. Northwest Tributary (385082) temporal distribution of total nitrogen concentrations and hydraulic discharge

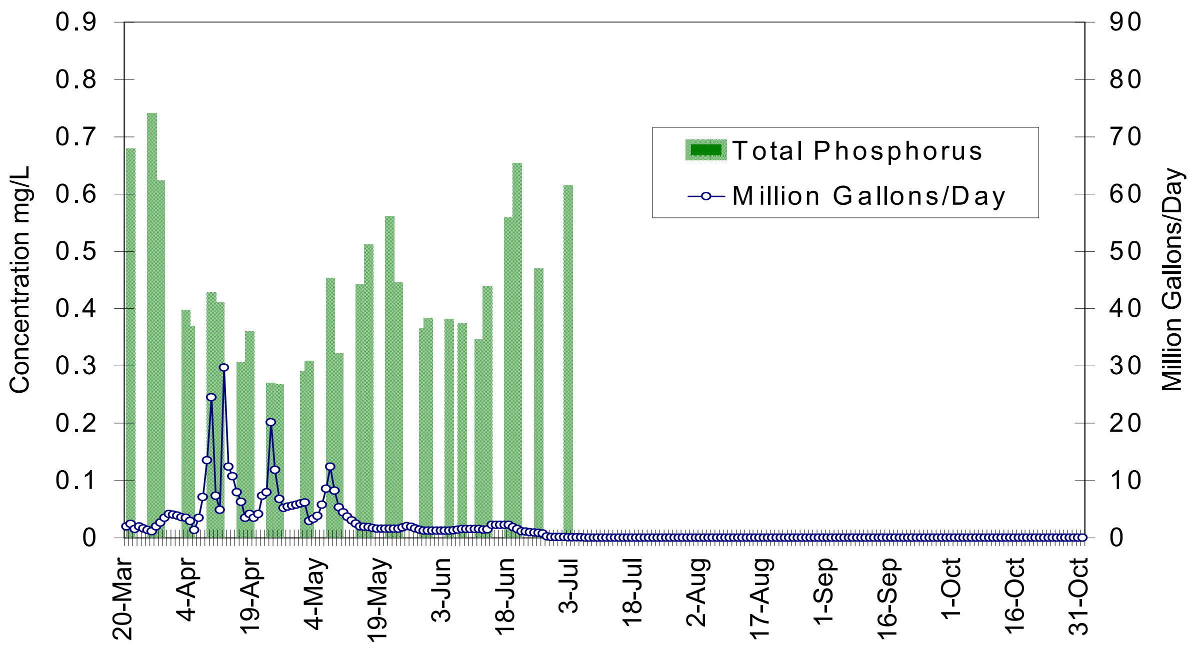


Figure 15. Northwest Tributary (385082) temporal distribution of total phosphorus concentrations and hydraulic discharge

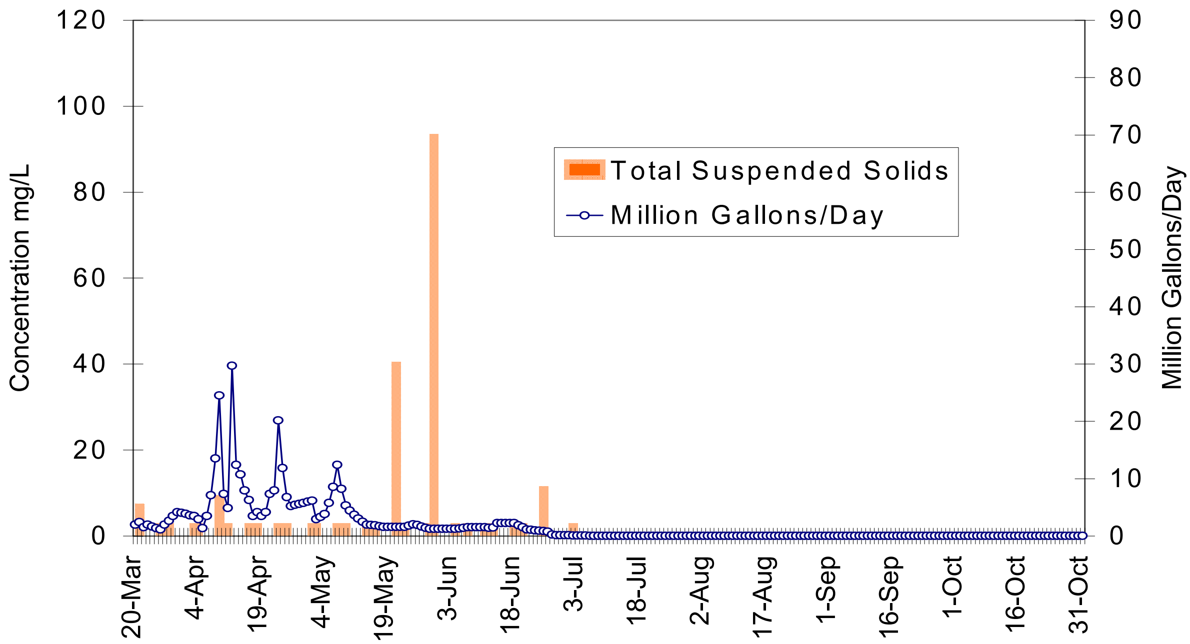


Figure 16. Northwest Tributary (385082) temporal distribution of total suspended solids concentrations and hydraulic discharge

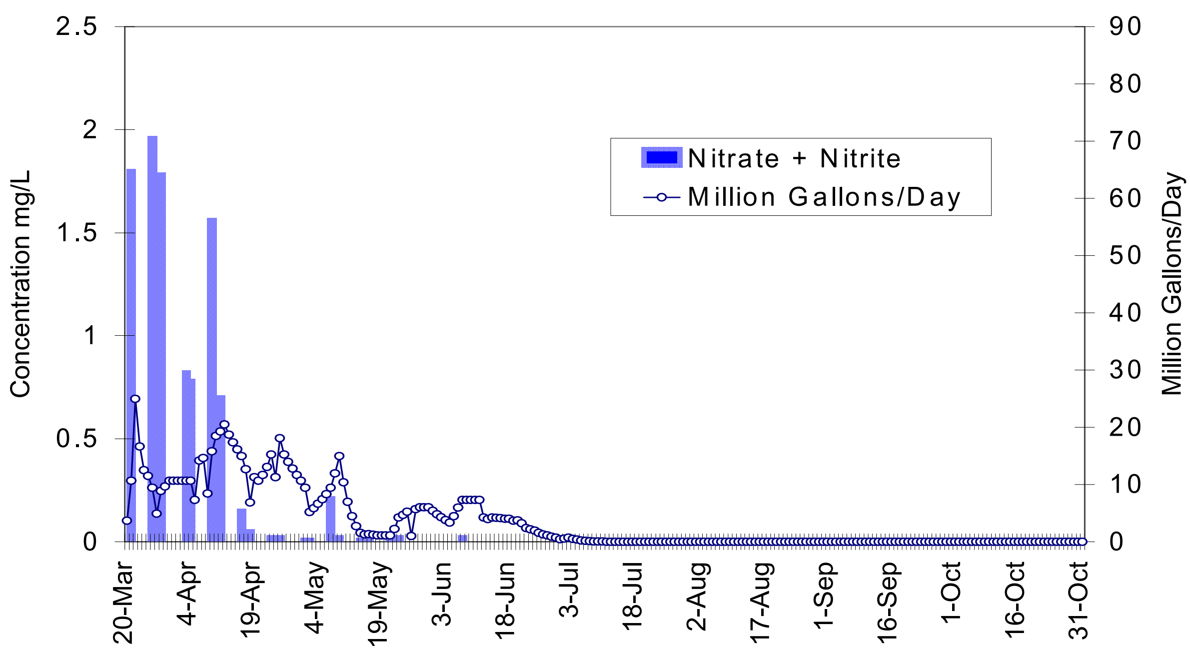


Figure 17. West Northwest Tributary (385081) temporal distribution of nitrate + nitrite as nitrogen concentrations and hydraulic distribution

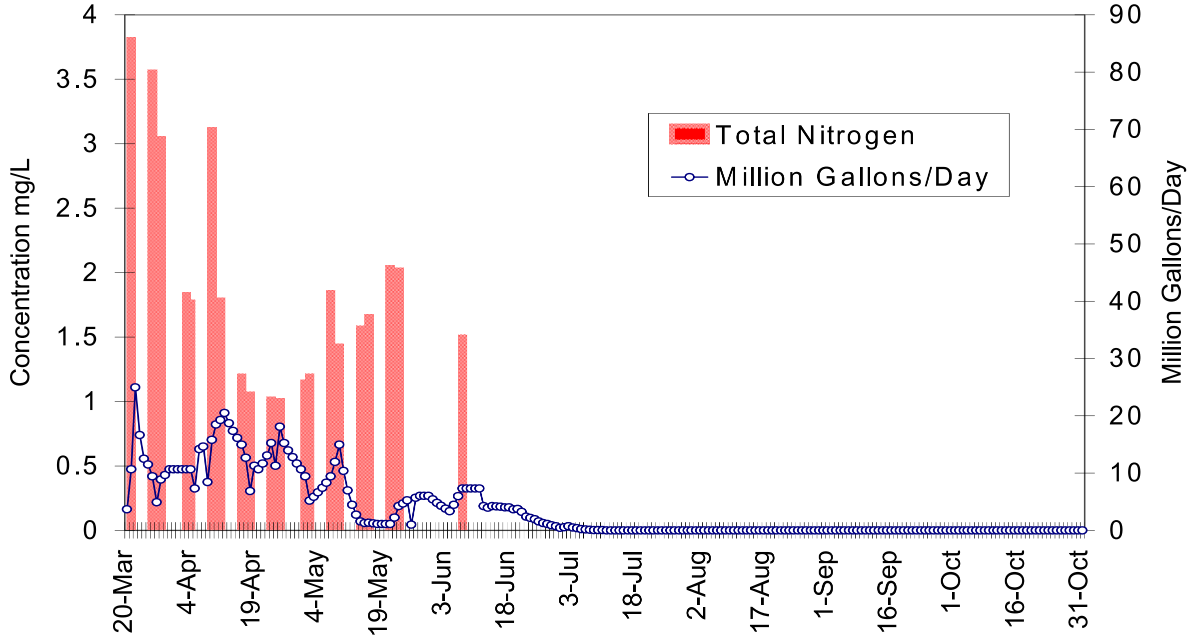


Figure 18. West Northwest Tributary (385081) temporal distribution of total nitrogen concentrations and hydraulic discharge

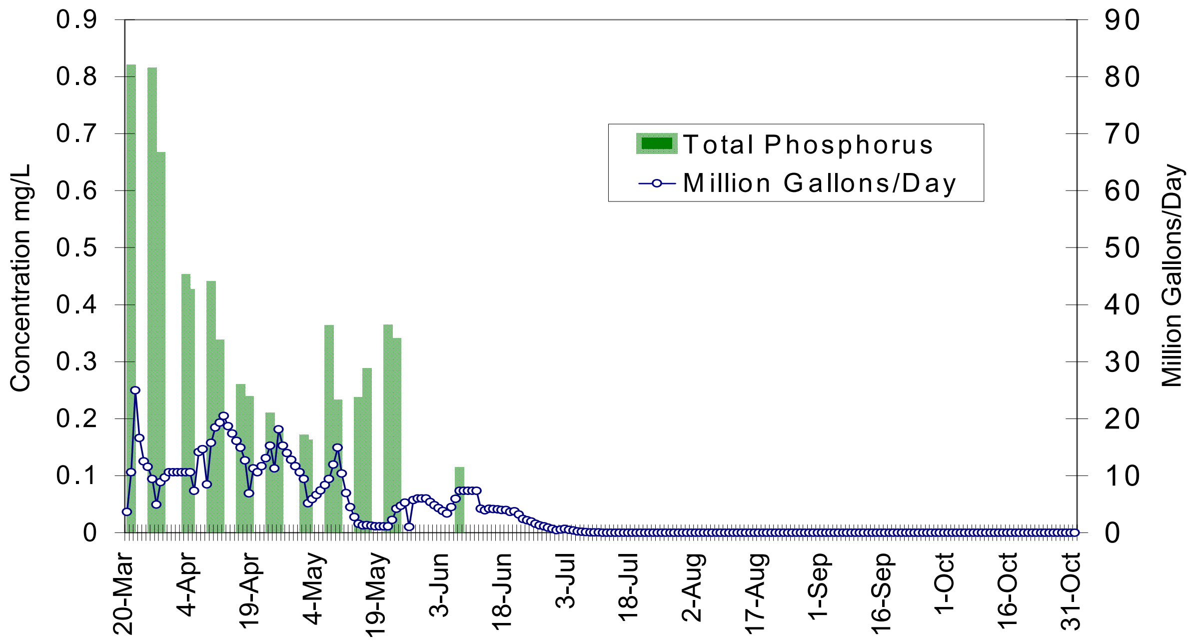


Figure 19. West Northwest Tributary (385081) temporal distribution of total phosphorus concentrations and hydraulic discharge

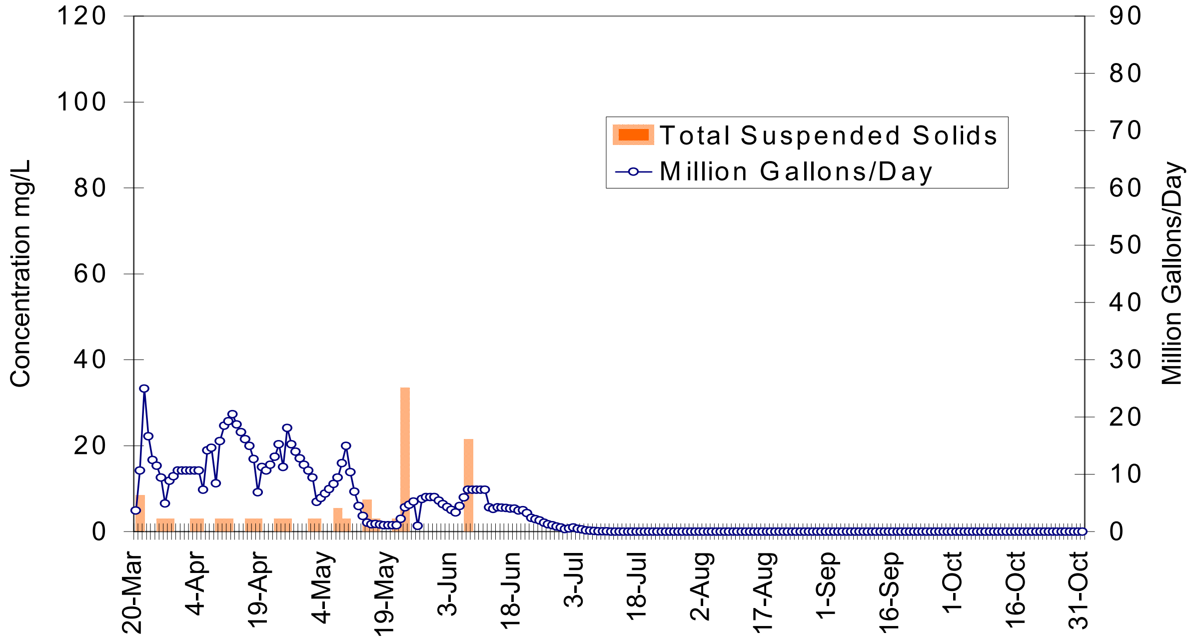


Figure 20. West Northwest Tributary (385081) temporal distribution of total dissolved solids concentrations and hydraulic discharge

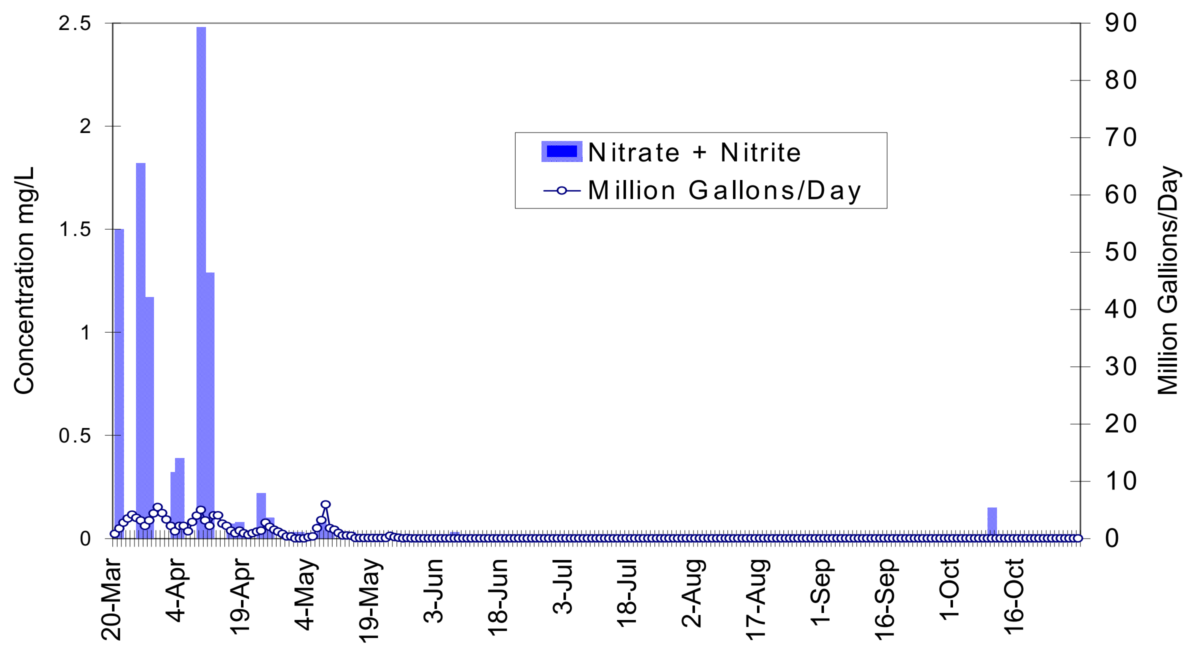


Figure 21. West Tributary (385080) temporal distribution of nitrate + nitrite as nitrogen concentrations and hydraulic discharge

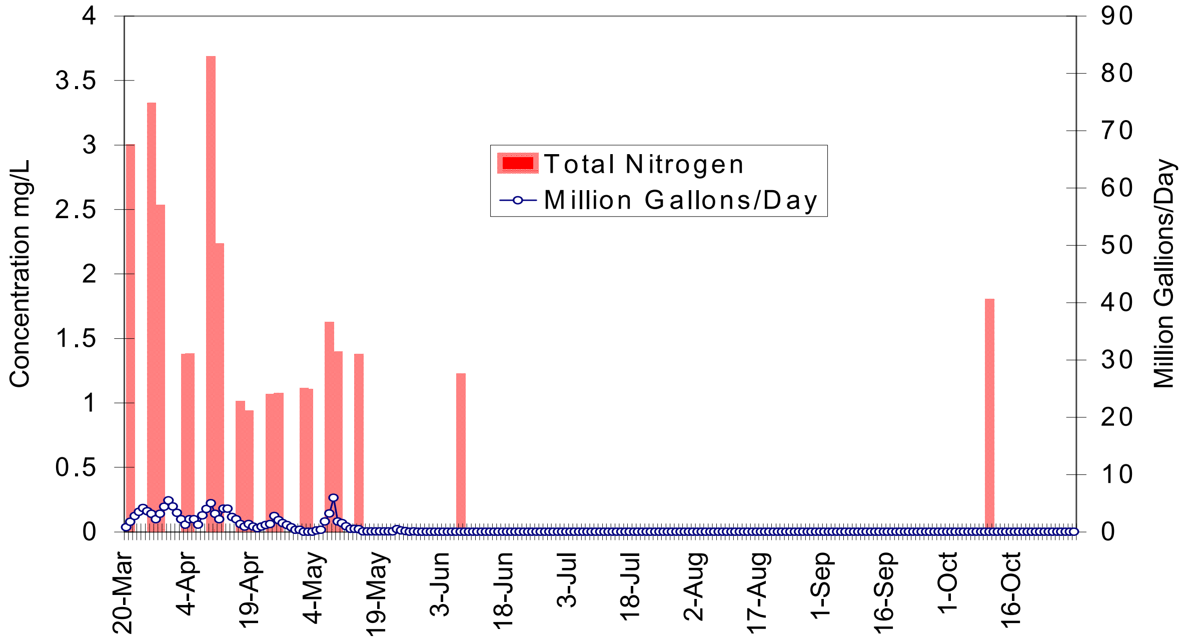


Figure 22. West Tributary (385080) temporal distribution of total nitrogen concentrations and hydraulic discharge

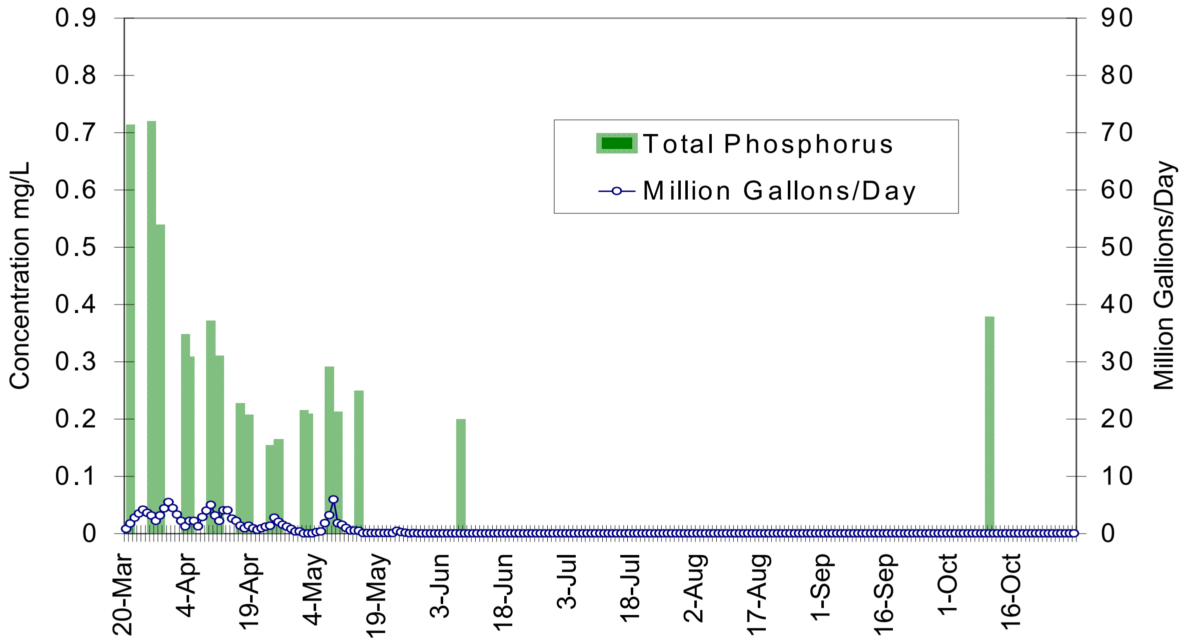


Figure 23. West Tributary (385080) temporal distribution of total phosphorus concentrations and hydraulic discharge

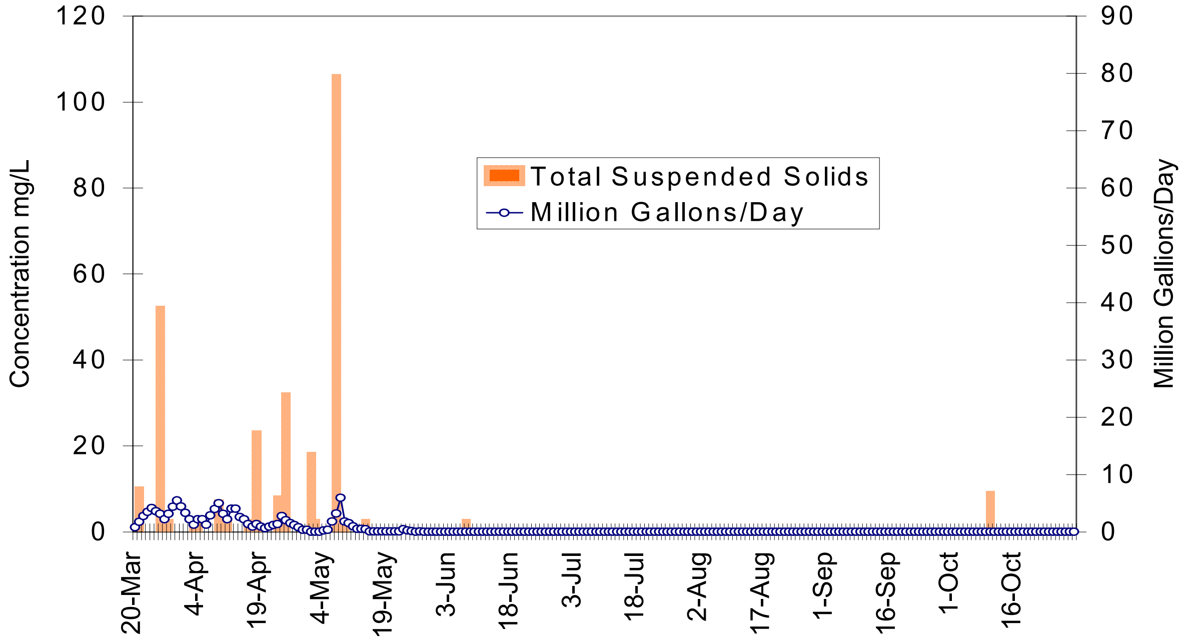


Figure 24. West Tributary (385080) temporal distribution of total suspended solids concentrations and hydraulic discharge

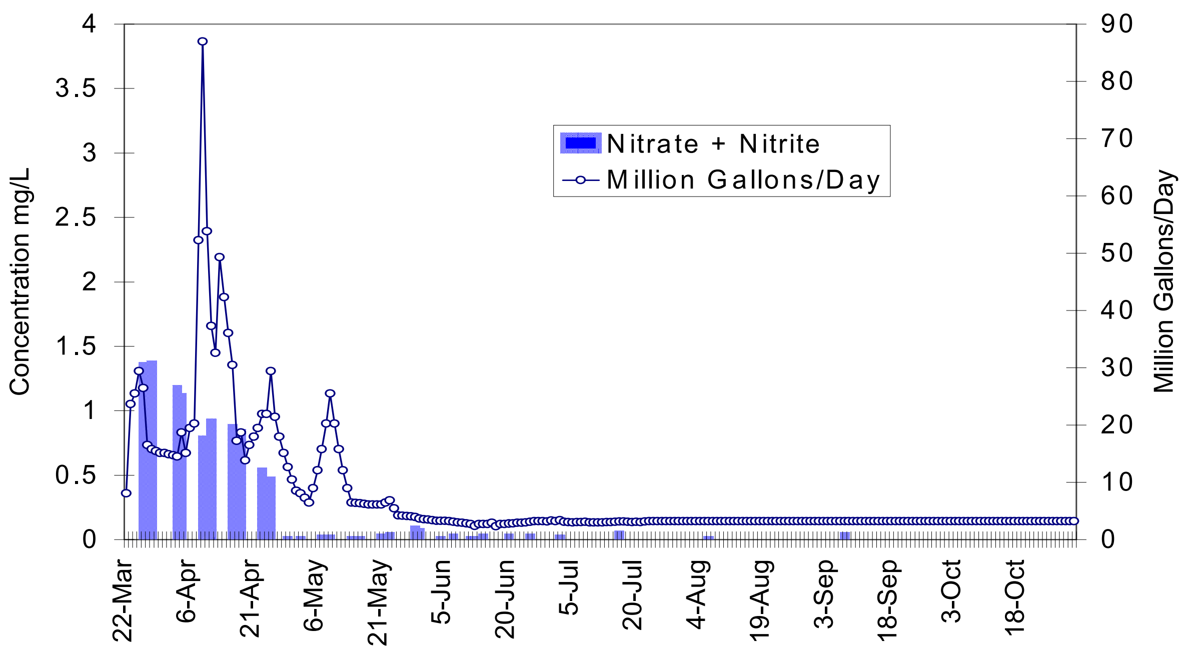


Figure 25. Pheasant Lake Outlet (380017) temporal distribution of nitrate + nitrite as nitrogen concentrations and hydraulic discharge

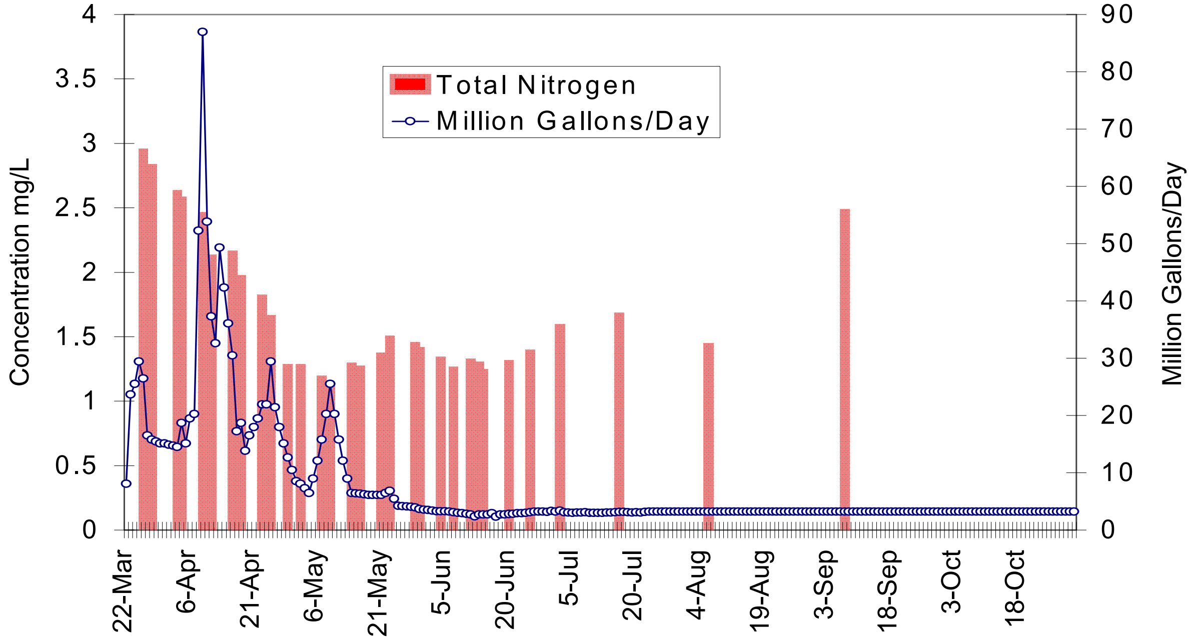


Figure 26. Pheasant Lake Outlet (380017) temporal distribution of total nitrogen concentrations and hydraulic discharge

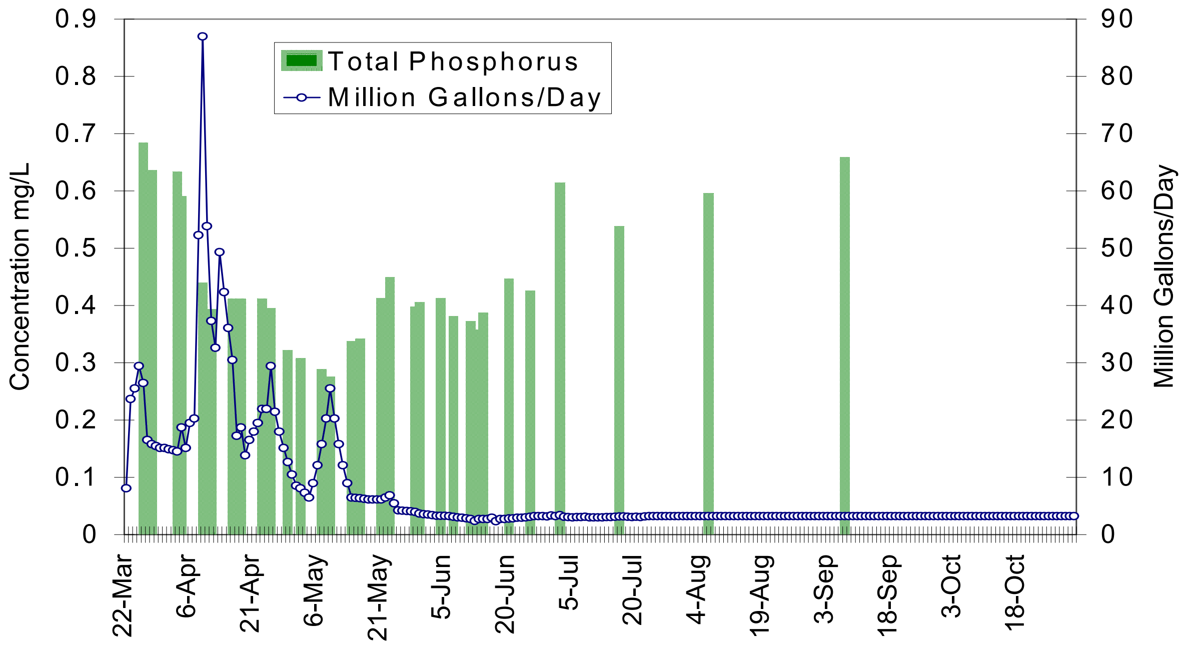


Figure 27. Pheasant Lake Outlet (380017) temporal distribution of total phosphorus concentrations and hydraulic discharge

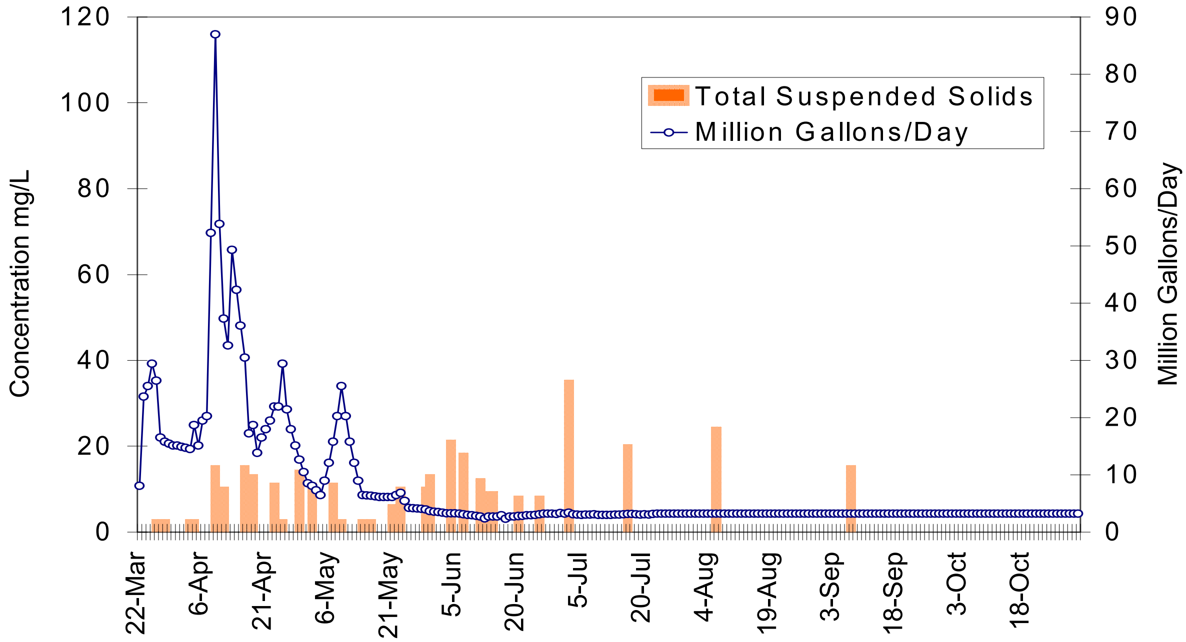


Figure 28. Pheasant Lake Outlet (380017) temporal distribution of total suspended solids concentrations and hydraulic discharge

2.7 Nutrient and Total Suspended Solids Yields Per Subwatershed

Pounds per acre yields of nitrate + nitrite as nitrogen, total nitrogen, total phosphorus, total suspended solids and water were estimated for the contributing watersheds (Elm River, Northwest Tributary, West Northwest Tributary and West Tributary). The yield estimates were calculated using the AGNPS model acreage and load estimates generated by the flux model.

The West Northwest Tributary (385081) had the highest yields per acre of nitrates + nitrite as nitrogen, total phosphorus and total nitrogen, and the West Tributary (385080) had the highest yields of total suspended solids. The Elm River (385083) had total phosphorus yields similar to the West Northwest Tributary (385081) with lower concentrations of nitrate + nitrite as nitrogen and total nitrogen and total suspended solids (Table 11) (Figures 29 through 32).

Table 11. Yield estimates in pounds/acre^2 per subwatershed

Station	Nitrate + Nitrite	Total Nitrogen	Total Phosphorus	Suspended Solids
Elm River (385083)	0.113	0.421	0.145	1.054
Northwest Tributary (385082)	0.089	0.391	0.076	1.058
West Northwest Tributary (385081)	0.236	0.826	0.156	2.254
West Tributary (385080)	0.189	0.434	0.075	4.556

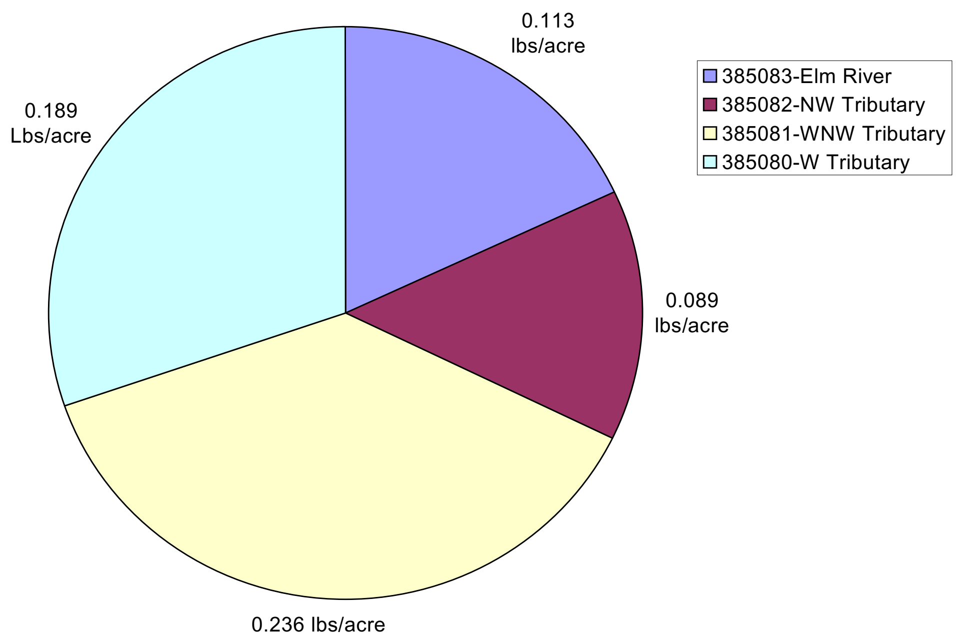


Figure 29. Nitrate + nitrite as nitrogen yields in pounds/acre

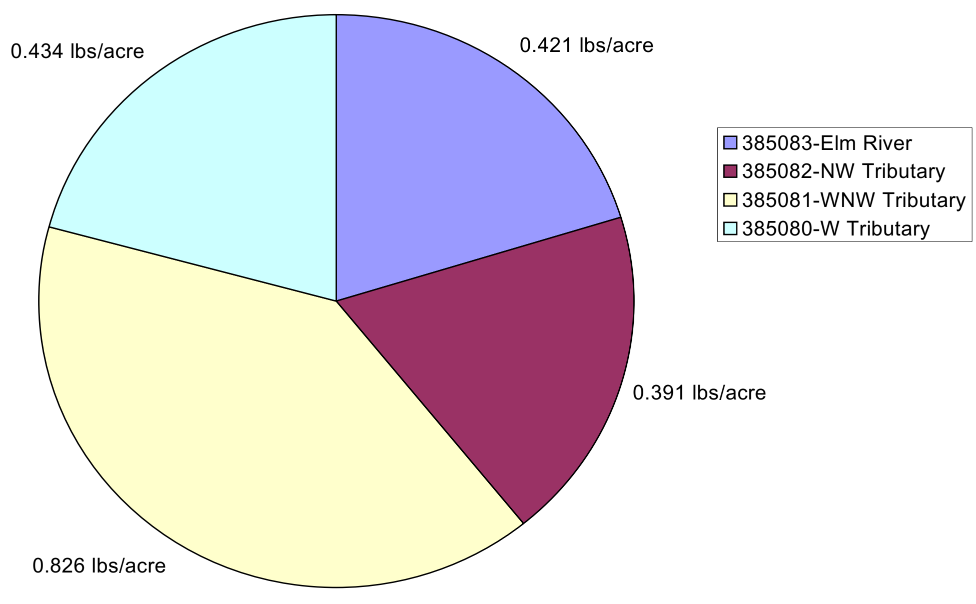


Figure 30. Total nitrogen yields in pounds/acre

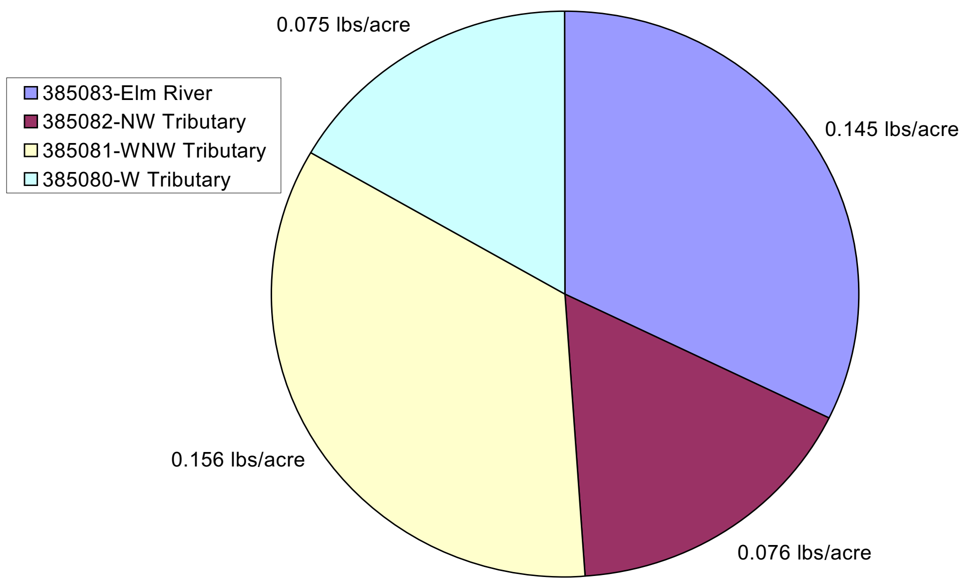


Figure 31. Total phosphorus yields in pounds/acre

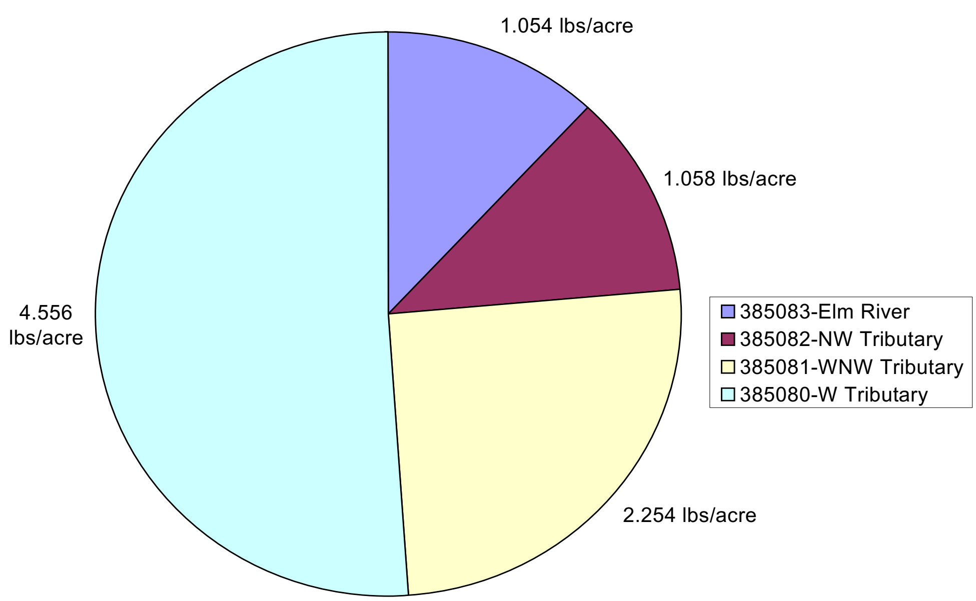


Figure 32. Total suspended solids yields in pounds/acre

3.0 LAKE MONITORING AND MODELING RESULTS

3.1 Overview

Water quality data was collected from Pheasant Lake at three sites representing the inlet (381127), central (385094) and deepest (381125) areas of the reservoir (Figure 33). Samples were collected eight times during the open-water period and once under ice cover conditions. Analytes sampled included nitrate + nitrite as nitrogen, total ammonia as nitrogen, total nitrogen, total dissolved phosphorus, total phosphorus and chlorophyll-a & b. Physical measurements collected were dissolved oxygen and temperature profiles, secchi disk depth transparency and general ambient weather condition.

The inlet and central areas of the lake were sampled at a depth of ½ meter, and the deepest area was sampled at three discrete depths. The three depths were at ½ meter, mid-depth, and ½ meter off the bottom unless thermal stratification was identified. If thermal stratification was occurring, then the depths were modified to ½ meter below the surface, the center of the metalimnion and ½ meter off the bottom. Chlorophyll-a & b was collected only over the deepest area only using a 6-foot depth integrated sampler. A complete quality assurance plan is contained in Appendix A.

In total 41 lake samples were collected, and the mean concentration calculated for nine dates (Table 12). In brief, the water quality data collected indicates that Pheasant Lake is nutrient rich enough to be hypereutrophic, biologically responds eutrophically, is nitrogen-limited, and periodically experiences weak thermal stratification.

Table 12. Pheasant Lake mean concentrations of select nutrients in mg L^{-1}

Date	Total Ammonia	Nitrate Nitrite	Total Nitrogen	Total Dis. Phosphorus	Total Phosphorus	Chlorophyll-a
Jun 4	0.017	0.01	1.275	0.441	0.383	NC
Jun 22	0.015	0.01	1.263	0.455	0.399	0.5
Jul 25	0.014	0.01	1.580	0.601	0.534	12.0
Aug 2	0.010	0.01	1.643	0.677	0.570	13.0
Aug 16	0.020	0.01	1.580	0.613	0.493	30.0
Aug 29	0.073	0.01	1.580	0.644	0.545	15.0
Sep 20	0.030	0.02	1.510	0.516	NC[1]	0.5
Oct 29	0.029	0.01	1.460	0.545	NC	NC
Feb 7	0.005	0.01	1.630	0.458	0.458	NC

[1]NC: Not collected

3.2 Trophic Condition

Pheasant Lake's trophic condition was assessed as eutrophic using Carlson's Trophic Status Index (TSI). Carlson's TSI uses a mathematical relationship based on the three indicators; secchi disk depth transparency in meters, total phosphorus in $\mu g\ L^{-1}$ and chlorophyll-a in $\mu g\ L^{-1}$. This numerical value then corresponds to a trophic condition ranging from zero to 100 with increasing values indicating a more eutrophic condition (Figure 34). Carlson's TSI estimates are calculated using the following equations:

Secchi Disk TSI = 60 - 14.41 ln (SD) where SD equals depth in meters

Phosphorus TSI = 14.20 ln (TP) + 4.15 where TP equals total phosphorus in $\mu g\ L^{-1}$

Chlorophyll-a TSI = 9.81 ln (TC) +30.60 where TC equals Chlorophyll-a in $\mu g\ L^{-1}$

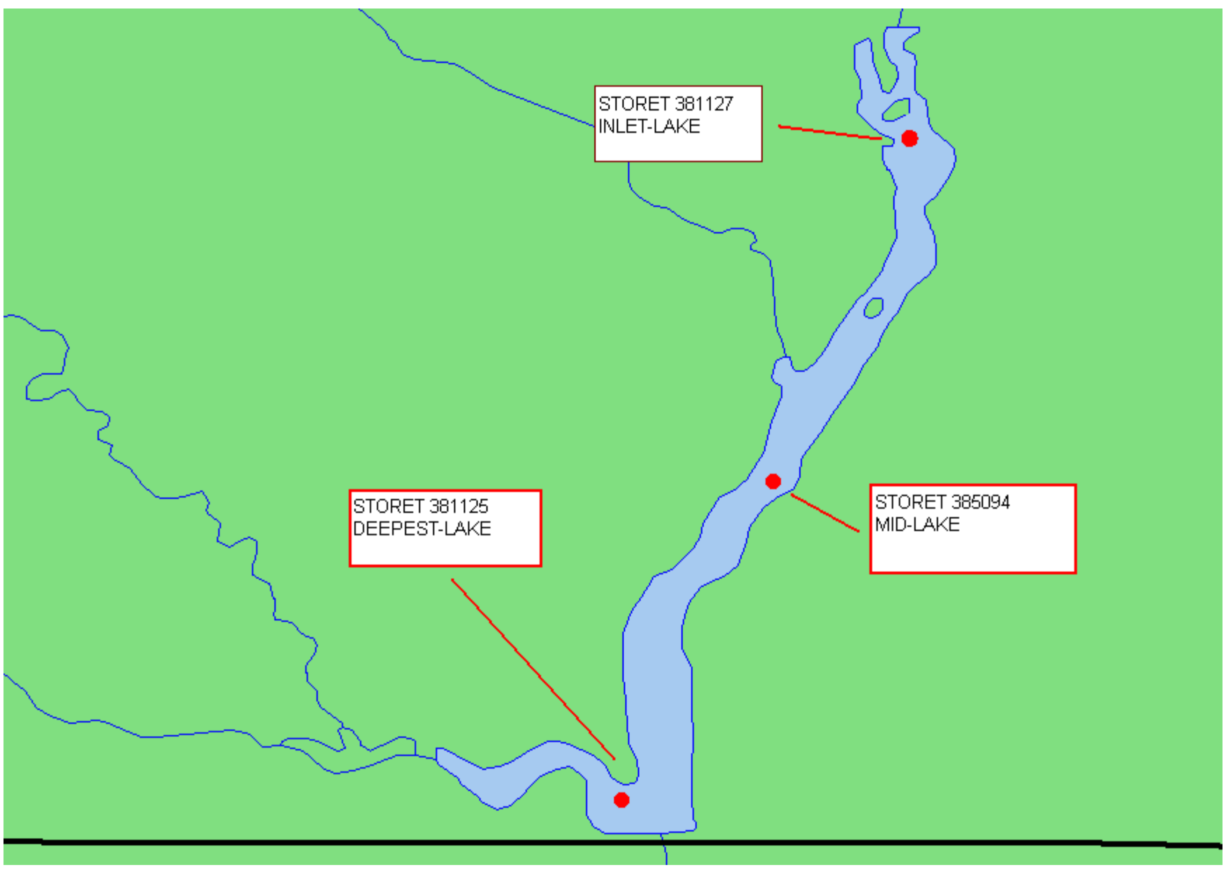


Figure 33. In-lake sampling sites on Pheasant Lake

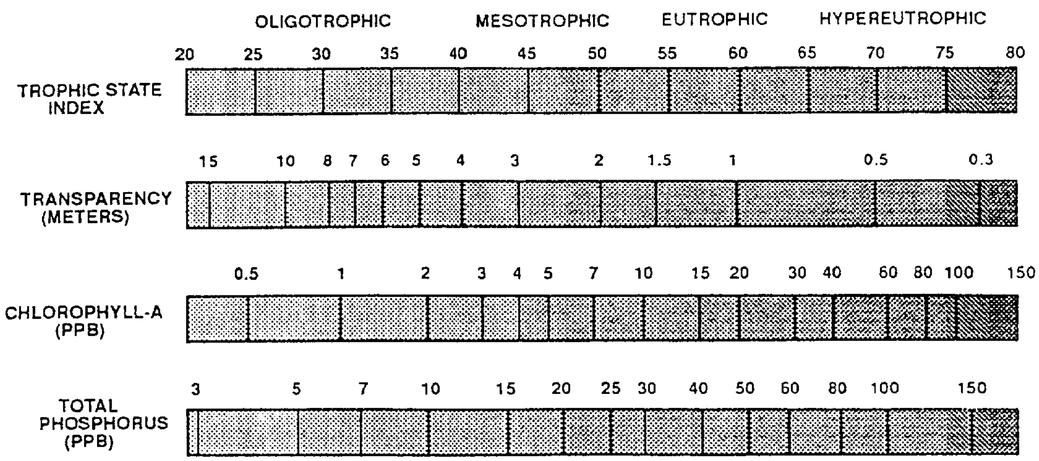


Figure 34. Carlson's trophic status index

Carlson TSI scores, using secchi disk depth transparency measurements at the deepest area ranged from a low of 52 to a high of 67 with a mean of 60, within the range of eutrophic. The temporal distribution shows a rise in trophic condition during the warmest and most productive period of the year (Figure 35). Carlson's TSI score, using chlorophyll-a & b, were lower but similar to the secchi disk scores, ranging from 31 to 65, indicating a trophic range of mesotrophic to eutrophic with a mean of 50 (representing the upper range of mesotrophic).

Carlson TSI scores, using total phosphorus, are significantly different then those of secchi disk transparency and chlorophyll-a & b. Phosphorus TSI scores had a vary small range of 91 to 97, all well within the hypereutrophic, if not distrophic, range (Figure35).

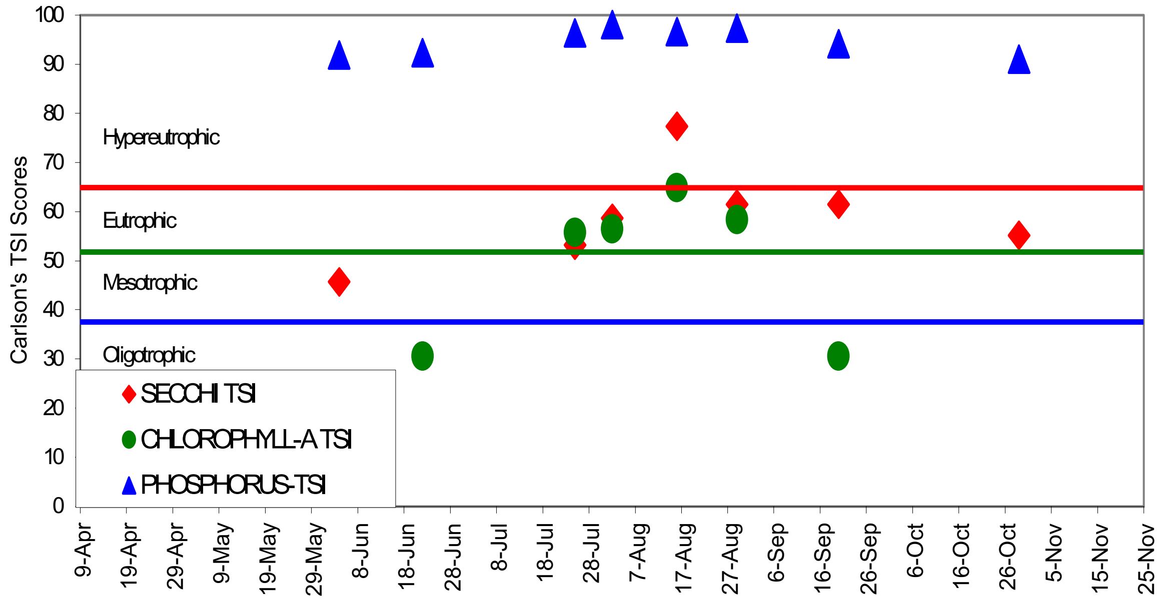


Figure 35. Pheasant Lake range of trophic status condition during open water 2001

3.3 Limiting Nutrient

Primary productivity within a water body is almost always driven by the nutrients nitrogen and phosphorus. By definition, a limiting nutrient is the one in short supply and, therefore, exerting control over primary production. A comparison of the ratios of nitrogen to phosphorus usually identifies which nutrient is limiting. Typically, a water body is at or near nutrient equilibrium with a ratio of 15 parts total nitrogen to 1 part of total phosphorus, or 10 parts inorganic nitrogen (nitrate + nitrite as nitrogen combined with total ammonia as nitrogen) to 1 part dissolved phosphorus. A ratio greater than 15 to 1 of total nitrogen to total phosphorus indicates phosphorus limitation, and a ratio less than 15 to1 indicates nitrogen limitation. A ratio greater than 10 parts inorganic nitrogen to dissolved phosphorus indicates phosphorus limitation, and a ratio less than 10 to 1 indicates nitrogen limitation.

When comparing the ratios of all nutrient samples collected at Pheasant Lake's deepest area, all samples showed a nitrogen shortage, strongly indicating that Pheasant Lake is nitrogen-limited. Total nitrogen to total phosphorus ratios ranged from a low of 2.4:1 to a high of 3.6:1, with the majority being below 3:1 (Figure 36). The ratios of inorganic nitrogen to dissolved phosphorus ranged from 0.01:1 to 0.12:1, with the majority being near or below 0.1:1 (Figure 37).

It is important to note that a shortage of nitrogen is rarely limiting in a lake system. Instead, this condition favors less desirable species of algae that are able to affix free nitrogen and dominate the entire photic zone.

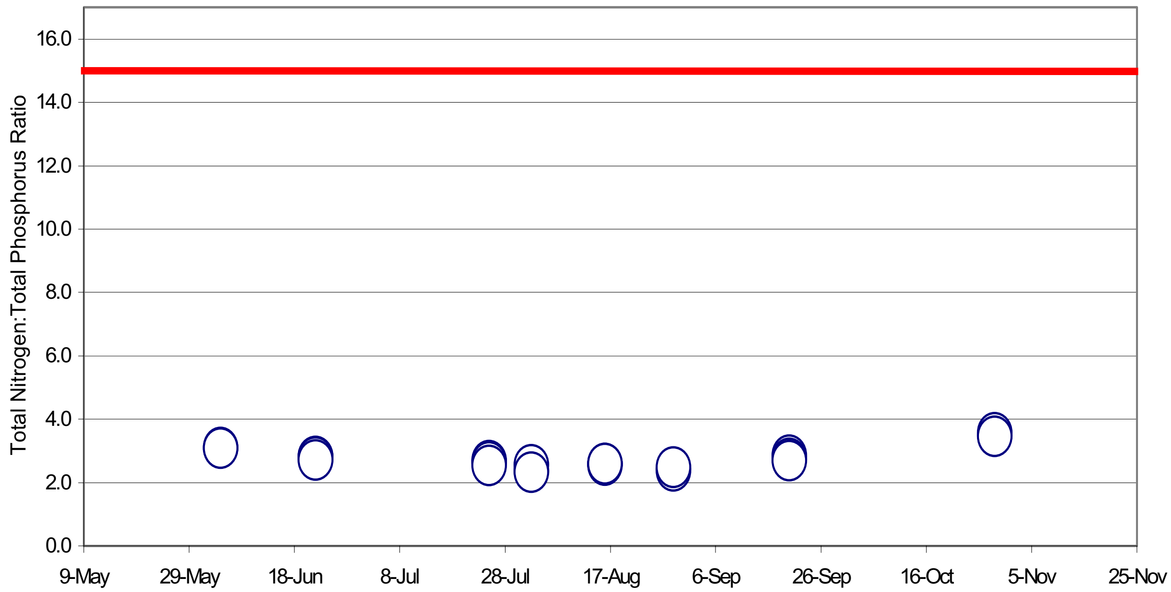


Figure 36. Total nitrogen to total phosphorus ratios.

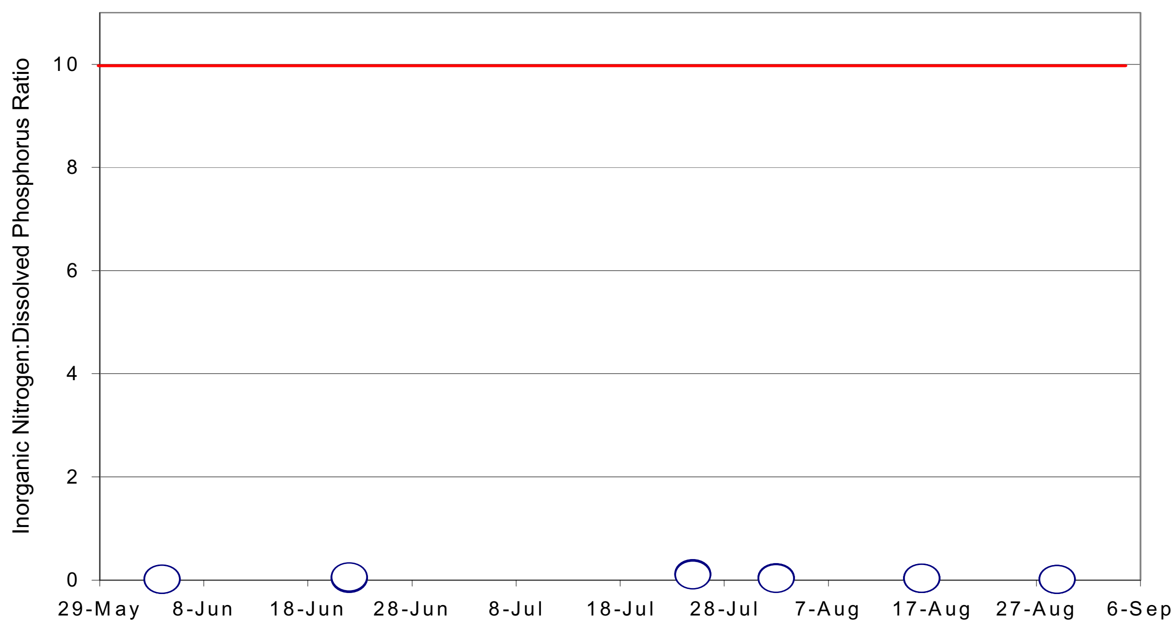


Figure 37. Inorganic nitrogen to dissolved phosphorus ratios

3.4 Thermal Stratification and Dissolved Oxygen Concentrations

At no time during the open water period of 2001 or ice cover of 2001-2002 did Pheasant Lake develop strong thermal stratification. Profiles collected at the three in-lake monitoring sites indicate the inlet and deepest areas do not thermally stratify, and the middle area experiences periodic weak thermal stratification during the hottest times of the summer (Figures 38 through 40).

Dissolved oxygen concentrations dropped below the state's minimum standard concentration of 5.0 mg L^{-1} at varying depths throughout the year. The hot summer months appear to be the most critical time period for maintaining dissolved oxygen concentrations, as concentrations dropped below the state standard of 5.0 mg L^{-1} at a depth of approximately 7 feet at the inlet site, and 9 feet at the mid-lake site on the sampling dates of July 25, August 2 and August 29 (Figure 41 through 43).

The deepest area of Pheasant Lake also had periods of low dissolved oxygen concentrations on these same dates, as well as on January 9. The dissolved oxygen concentrations at the deepest area site dropped below 5.0 mg L^{-1} between a depth of 8 and 12 feet on July 24, August 2 and January 9, and in the entire water column on August 29.

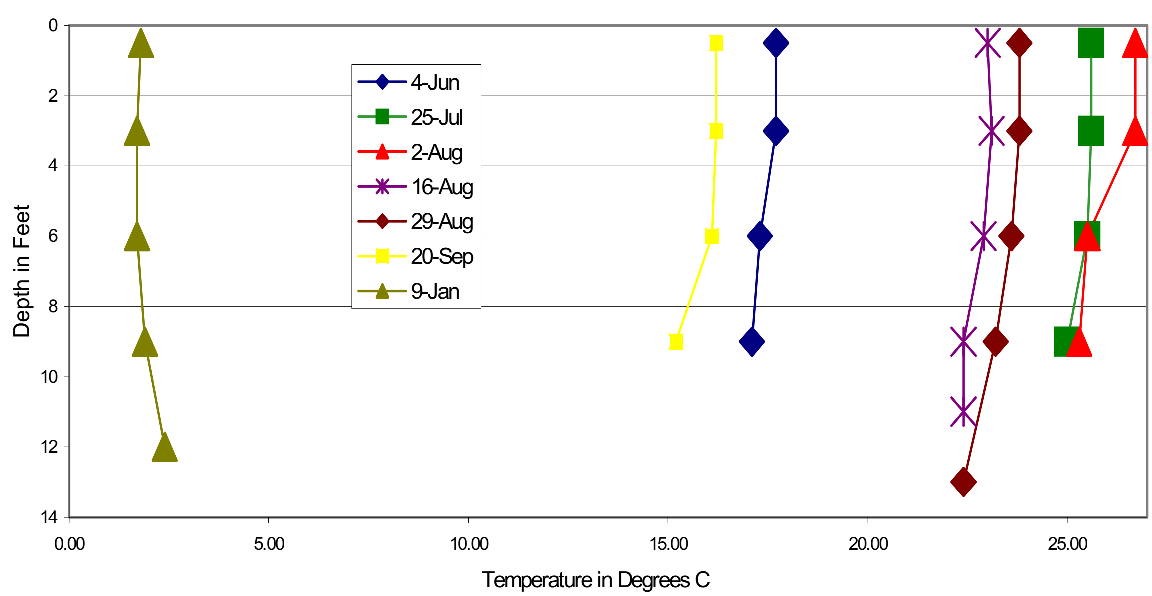


Figure 38. Pheasant Lake inlet area temperature profiles

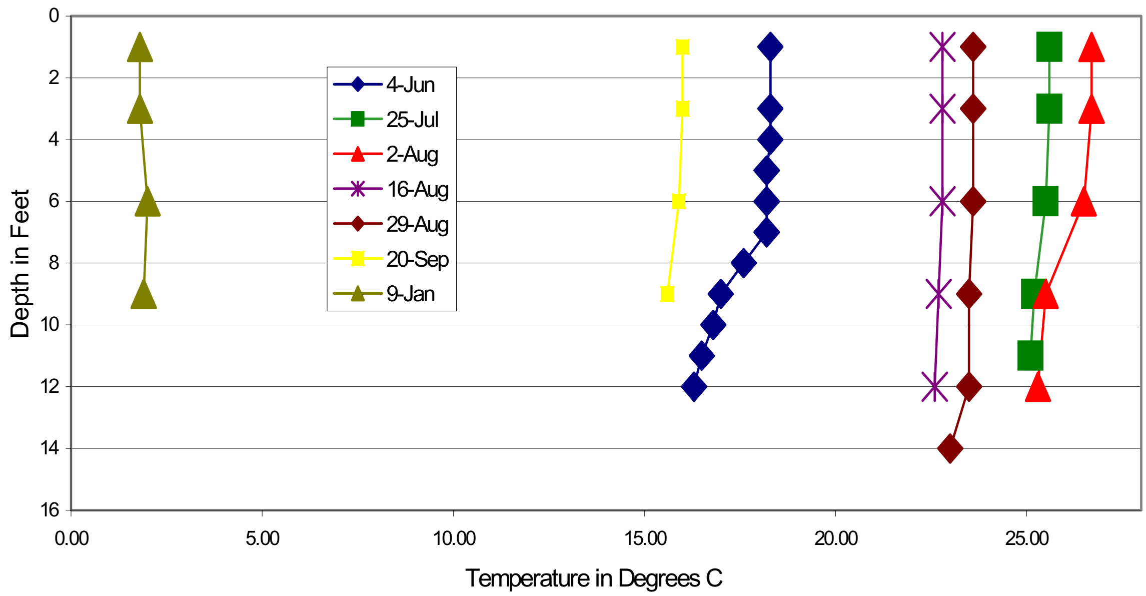


Figure 39. Pheasant Lake mid-lake area temperature profiles

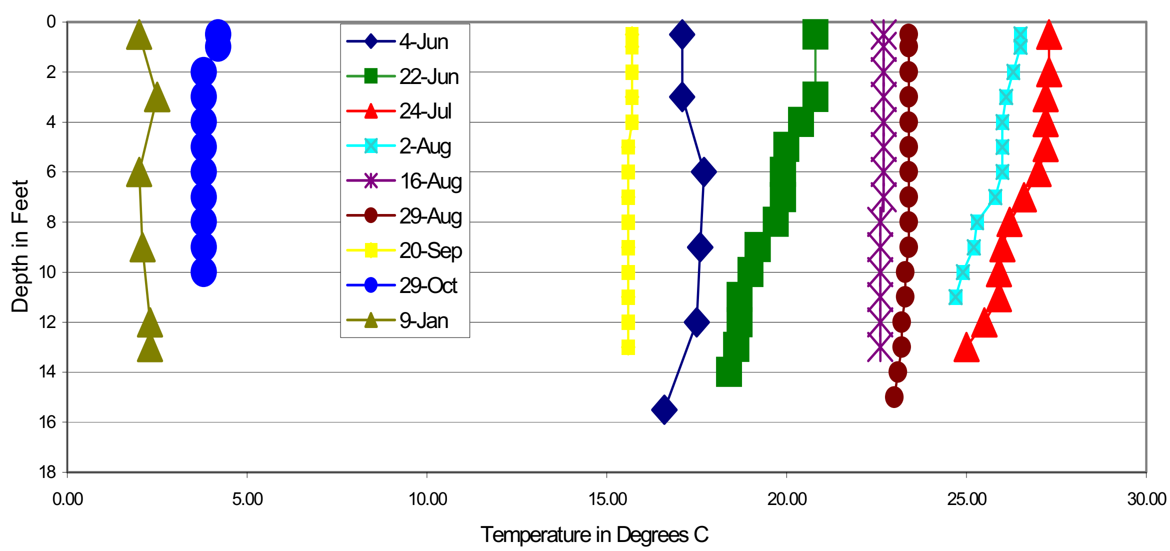


Figure 40. Pheasant Lake deepest area temperature profiles

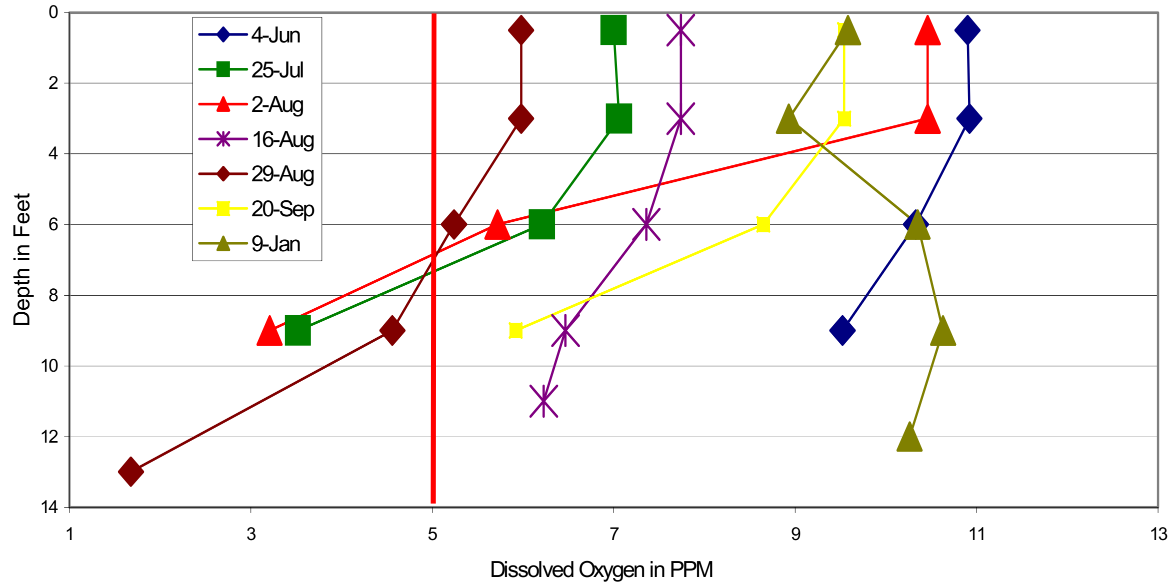


Figure 41. Pheasant Lake inlet area dissolved oxygen profiles

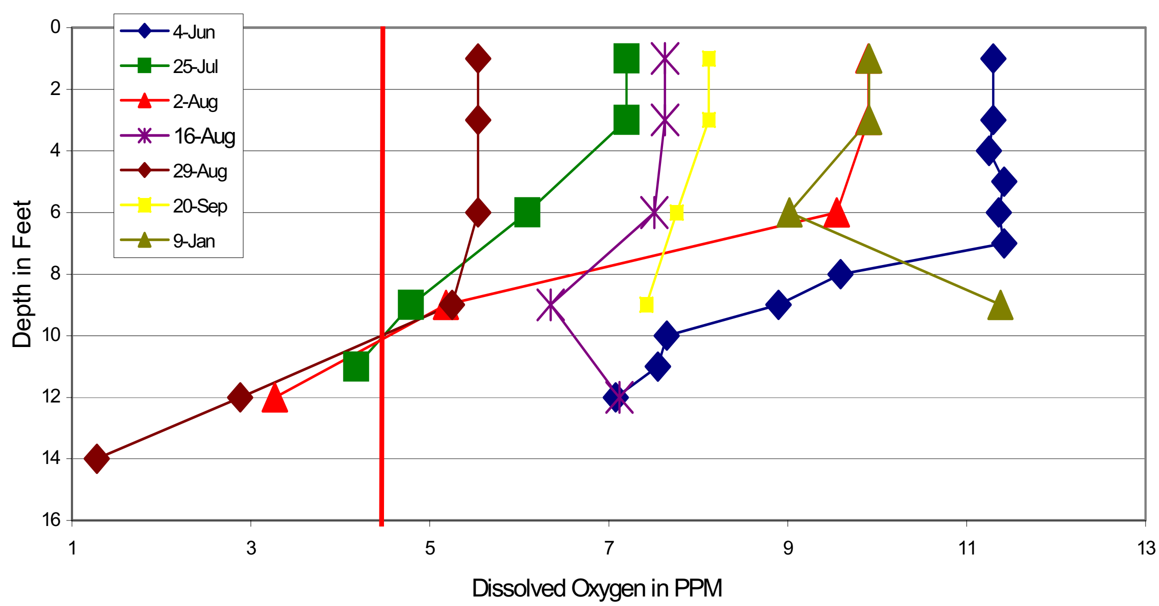


Figure 42. Pheasant Lake mid-lake area dissolved oxygen profiles

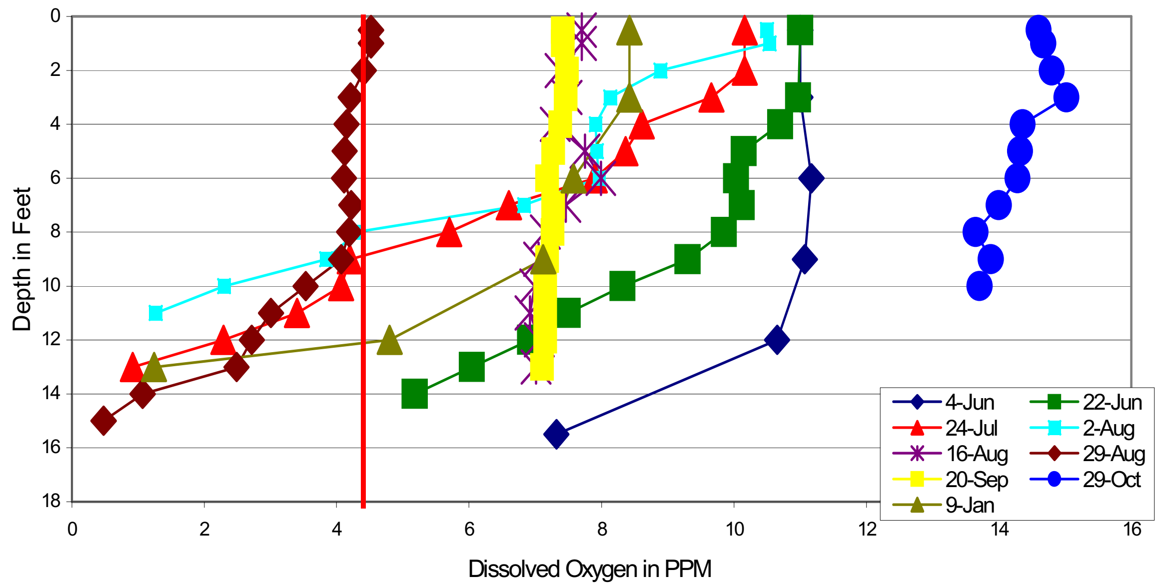


Figure 43. Pheasant Lake deepest area dissolved oxygen profiles

3.5 Lake Budget

Pheasants Lake's hydraulic, nutrient and suspended solids budgets were estimated using the upstream flows on the Elm River (385083), Northwest Tributary (385082), West Northwest Tributary (385081), West Tributary (385080) and the Outlet (Station 380017). During the 2001 open-water season, the four major tributaries and direct precipitation delivered an estimated 2,240.416 million gallons (8.48 HM^3) of water, 8,564.44 pounds (3,884.1 Kg) of total phosphorus, 28,958.456 pounds (13,133.1 Kg) of total nitrogen and 114,009.4 pounds (51,704.9 Kg) of suspended solids to Pheasant Lake.

During this same time period, Pheasant Lake discharged and evaporated 2,077.668 million gallons (7.864 HM^3) of water, 8,587.2 pounds (3994.4 Kg) of total phosphorus, 23,130.23 pounds (10,489.9 Kg) of total nitrogen and 164,626.63 pounds (74,660.7 Kg) of suspended solids. The net loss and gain in pollutants to Pheasant Lake for 2001 is estimated at -22.8 pounds (-10.3 Kg) of total phosphorus, 5828.23 pounds (2,643.2 Kg) of total nitrogen and -65,488.28 pounds (29,699.9 Kg) of suspended solids (Tables 13 through 16), (Figures 28 through 31).

To put this in perspective, Pheasant Lake was fertilized at a rate of 37 pounds/acre of phosphorus (P) and 275 pounds/acre of nitrogen (N) in 2001. This is in addition to the estimated internally available phosphorus and nitrogen of 10.3 and 27.9 pounds/acre, respectively, based on a lake volume of 1,700 acre feet and a surface area of 232 acres.

Table 13. Pheasants Lake water budget for 2001

Source	Million Gallon	HM^3
Precipitation	243.33	0.921
Elm River (385083)	583.88	2.210
Northwest Tributary (385082)	406.87	1.540
West Northwest Tributary (385081)	813.74	3.080
West Tributary (385080)	192.60	0.729
Evaporation	352.44	1.334
Outflow (380017)	1,725.23	6.530
Net Retention	0.00	0.000
Ungauged Outflow	162.75	0.616
Residence Time	0.276 years (100.74 days)	

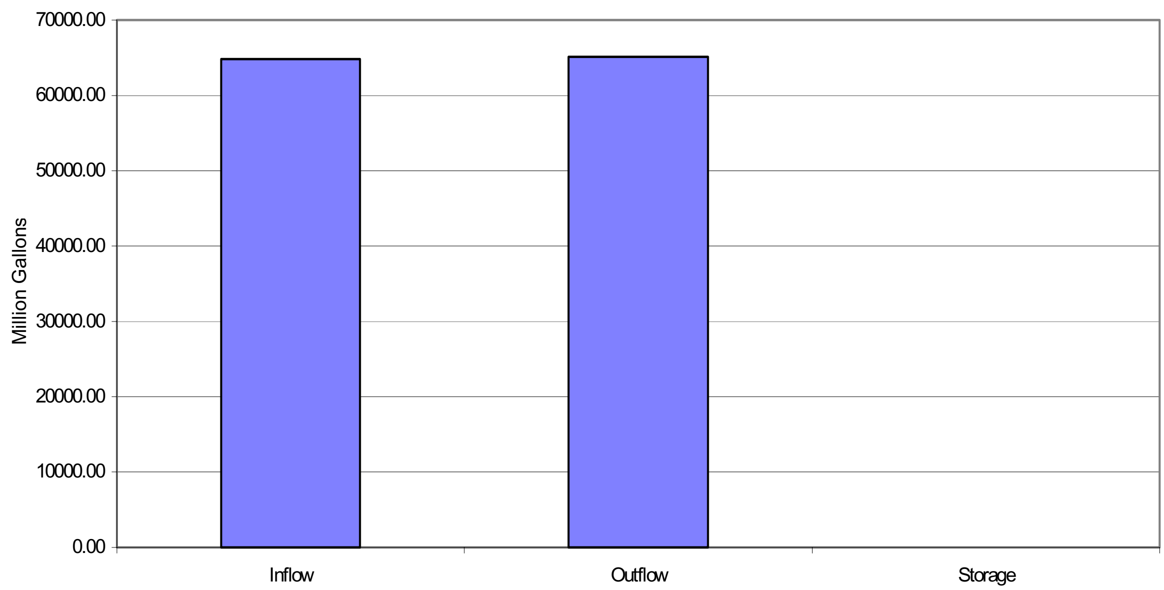


Figure 44. Pheasant Lake 2001 water budget in millions of gallons

Table 14. Pheasant Lake's total phosphorus budget for 2001

Source	Pounds	Kg
Precipitation	123.26	55.9
Elm River (385083)	2845.33	1290.4
Northwest Tributary (385082)	1747.90	792.7
West Northwest Tributary (385081)	3053.04	1384.6
West Tributary (385080)	795.34	360.7
Outflow (380017)	7847.37	3558.9
Ungauged Outflow	739.99	335.6
Net Retention	-22.71	-10.3
Residence Time	0.276 years (100.74 days)	

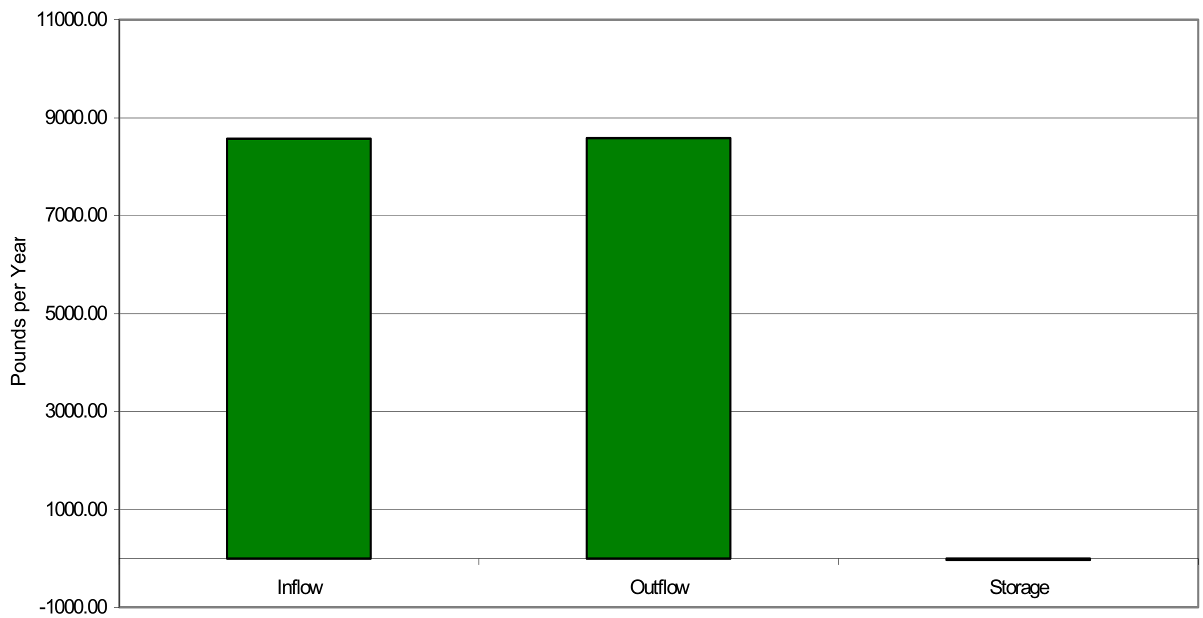


Figure 45. Pheasant Lake 2001 total phosphorus budget in pounds/year

Table 15. Pheasant Lake total nitrogen budget for 2001

Source	Pounds	Kg
Precipitation	2040.07	925.2
Elm River (385083)	8200.62	3719.1
Northwest Tributary (385082)	5241.73	2377.2
West Northwest Tributary (385081)	10170.34	4612.4
West Tributary (385080)	3305.74	1499.2
Outflow (380017)	21137.13	9586.0
Ungauged Outflow	1993.10	903.9
Net Retention	5828.26	2643.2
Residence Time	0.276 years (100.74 days)	

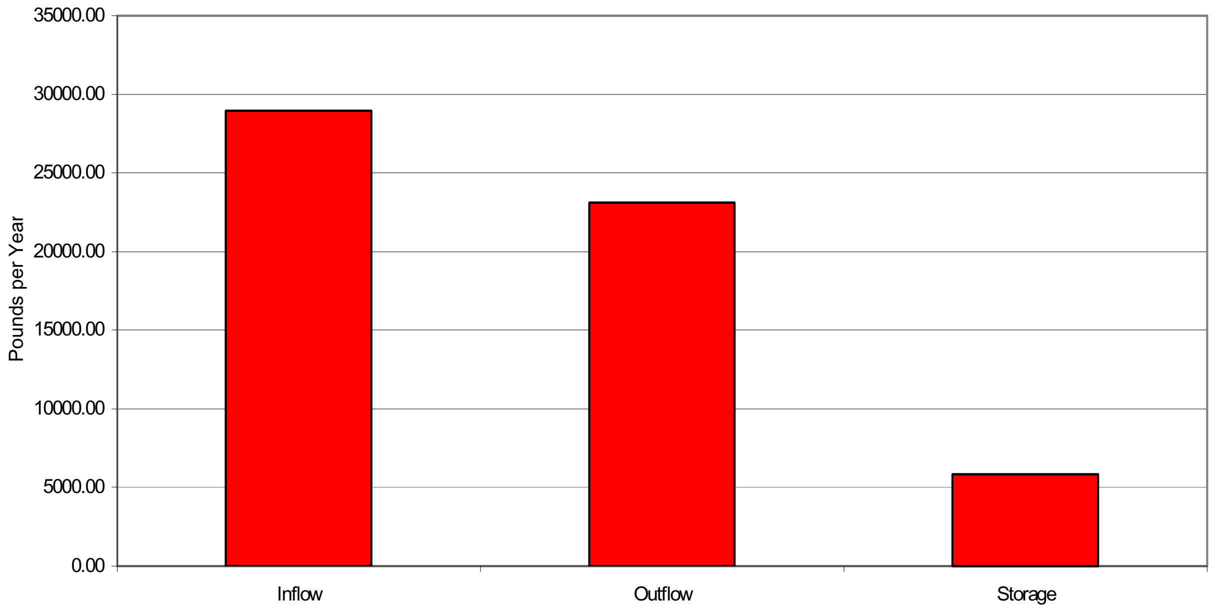


Figure 46. Pheasant Lake 2001 total nitrogen budget in pounds/year

Table 16. Pheasant Lake total suspended solids budget for 2001

Source	Pounds	Kg
Elm River (385083)	25170.08	11415.0
Northwest Tributary (385082)	18371.84	8331.9
West Northwest Tributary (385081)	33183.27	15049.1
West Tributary (385080)	22413.38	10164.8
Outflow (380017)	164713.28	74699.9
Net Retention	99138.56	44960.8

Residence Time 0.276 years (100.74 days)

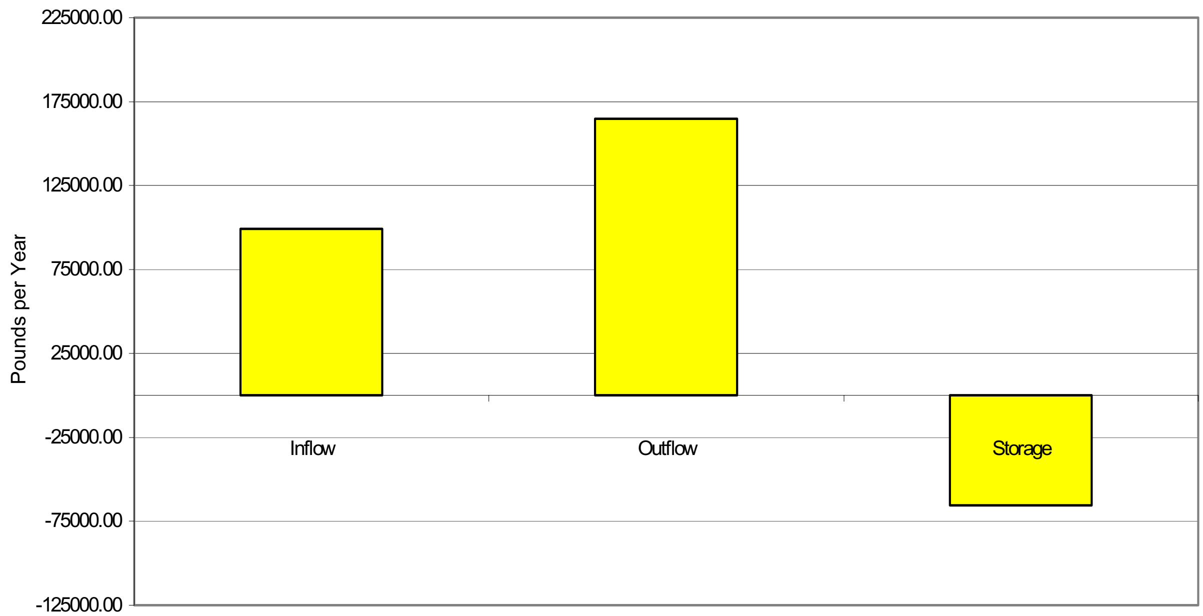


Figure 47. Pheasant Lake 2001 total suspended solids budget in pounds/year

3.6 Pheasant Lake's Trophic Response and Calibrated Bathtub Model Results

Pheasant Lake's observed and calibrated model nutrient (total phosphorus and total nitrogen), biological (Chlorophyll-a) and physical (secchi disk) responses for 2001 are displayed in Table 17. The trophic response model used in this analysis is the U.S. Army Corps of Engineers bathtub model. The bathtub model has a number of fixed options available. For Pheasant Lake, model option three and a fixed decay rate of one for nitrogen and phosphorus was selected. Of note, total dissolved phosphorus was substituted for orthophosphorous for this model. A complete set of bathtub model input and output files are contained in Appendix D.

Table 17. Pheasant Lake observed and calibrated trophic response model

	Value	
Variable	Observed	Modeled
Total Phosphorus (mg L^{-1})	0.545	0.545
Total Nitrogen (mg L^{-1})	1.468	1.468
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.108
Chlorophyll-a (Fg L^{-1})	19.25	19.16
Secchi disk depth (m)	0.96	0.96
Carlson's TSI Phosphorus	95.01	95.01
Carlson's TSI Chlorophyll-a	59.61	59.57
Carlson's TSI Secchi	60.51	60.52

3.7 Trophic Response Modeling

Lake trophic response is a product of nutrient availability measured by the amount of chlorophyll-a present and secchi disk depth. Nutrient availability for eutrophication is a product of residence time and nutrient concentration. The nutrient in abundance in Pheasant Lake is phosphorus. In practical terms, the higher the phosphorus concentration and the longer it is stored, the greener Pheasant Lake will become.

The objective of developing a trophic response model for Pheasant Lake is to predict the amount of reduction in trophic response that can be expected with a known decrease in nutrient load using a fixed residence time. The target set for this exercise is a trophic response within Carlson's TSI range of eutrophic, using chlorophyll-a and secchi disk as the indicators.

Two sets of simulations were run. The first set addressed only external phosphorus and nitrogen loading. This was accomplished by running a series of simulations with reduced concentrations of instream nutrients in gradations of 25, 50, 75 and 90 percent, without changing the hydraulics entering and exiting the lake.

The second set of simulations addressed internal and external nutrient load. These simulations assumed a base lake condition resulting from a 50 percent reduction in external load (predicted by model) and decreases in internally available phosphorus and nitrogen of 25, 50, 75 and 90 percent.

Internally available nutrients were calculated by subtracting the difference between the measured in-lake concentrations of total phosphorus and total nitrogen from the uncalibrated bathtub model predicted concentrations using a fixed decay rate of 1.0 for both total phosphorus and total nitrogen. Basically, it was assumed that the uncalibrated model reasonably predicted a zero internal load, using model option three and a decay rate of one. The model was then calibrated by reducing the decay rates of total phosphorus and total nitrogen. The decay rates were then increased by 25, 50, 75 and 90 percent to mimic decreasing internal load.

The first set of model runs, reducing just external pollution load only, predicted that external load would need to be reduced by a minimum of 50 percent in order to reduce the trophic response to a noticeable degree and obtain the goal of a Carlson TSI score of less than 60 for both chlorophyll-a and secchi disk (Tables 18 through 21), (Figure 48).

The second set of model runs simulated a decrease in external load of 50 percent, combined with reductions in internally available nutrients of 25, 50, 75 and 90 percent. As with the first set of simulations, the hydraulic inflow and outflow remained constant. The results of this exercise predicted very little gain from controlling internally stored nutrient, as even a 90 percent reduction in external load netted only minimal improvements in trophic response. This exercise indicates that Pheasant Lake's trophic condition is externally driven, or a significant nutrient source was not accounted for (Tables 22 through 25), (Figure 49).

Two of the factors affecting internally available nutrients within Pheasant Lake are an aeration system and hypolimnetic draw down. The aeration system is normally operational for the duration of the ice-covered period, and the hypolimnetic draw down is opened in late winter or early spring and allowed to run through late spring or early summer, depending on lake levels. In combination, the two systems prevent the lake from thermally stratifying, thereby reducing internal cycling of nutrients and discharging nutrient-rich waters from the hypolimnion.

Table 18. Pheasant Lake observed and calibrated trophic response model with a 25 percent reduction in external loads of total phosphorus and total nitrogen

	Value	
Variable	Observed	Model - 25 % Reduction
Total Phosphorus (mg L^{-1})	0.545	0.402
Total Nitrogen (mg L^{-1})	1.468	1.133
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.080
Chlorophyll-a (Fg L^{-1})	19.250	18.450
Secchi disk depth (m)	0.960	1.220
Carlson's TSI Phosphorus	95.010	90.620
Carlson's TSI Chlorophyll-a	59.610	59.200
Carlson's TSI Secchi	60.590	57.180

Table 19. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external loads of total phosphorus and total nitrogen

	Value	
Variable	Observed	Model - 50 % Reduction
Total Phosphorus (mg L^{-1})	0.545	0.276
Total Nitrogen (mg L^{-1})	1.468	0.786
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.052
Chlorophyll-a (Fg L^{-1})	19.250	17.180
Secchi disk depth (m)	0.960	1.710
Carlson's TSI Phosphorus	95.010	85.200
Carlson's TSI Chlorophyll-a	59.610	58.500
Carlson's TSI Secchi	60.590	52.250

Table 20. Pheasant Lake observed and calibrated trophic response model with a 75 percent reduction in external loads of total phosphorus and total nitrogen

	Value	
Variable	Observed	Model - 75 % Reduction
Total Phosphorus (mg L^{-1})	0.545	0.142
Total Nitrogen (mg L^{-1})	1.468	0.454
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.025
Chlorophyll-a (Fg L^{-1})	19.250	13.720
Secchi disk depth (m)	0.960	3.060
Carlson's TSI Phosphorus	95.010	75.620
Carlson's TSI Chlorophyll-a	59.610	56.290
Carlson's TSI Secchi	60.590	43.860

Table 21. Pheasant Lake observed and calibrated trophic response model with a 90 percent reduction in external loads of total phosphorus and total nitrogen

	Value	
Variable	Observed	Model - 25 % Reduction
Total Phosphorus (mg L^{-1})	0.545	0.064
Total Nitrogen (mg L^{-1})	1.468	0.249
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.008
Chlorophyll-a (Fg L^{-1})	19.250	8.180
Secchi disk depth (m)	0.960	7.390
Carlson's TSI Phosphorus	95.010	64.180
Carlson's TSI Chlorophyll-a	59.610	51.300
Carlson's TSI Secchi	60.590	31.180

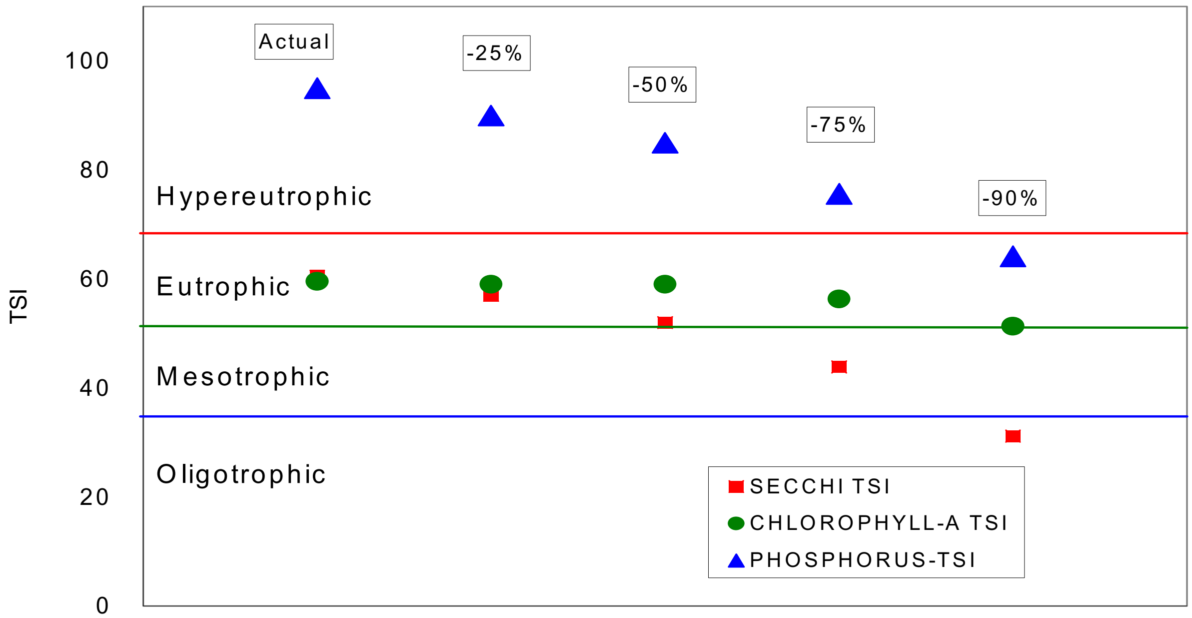


Figure 48. Pheasant Lake predicted trophic response to reductions in external nitrogen and phosphorus loads of 25, 50, 75 and 90 percent

Table 22. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external load and a 25 percent reduction in internally available total phosphorus and total nitrogen

Variable	Reduction -50% Observed	Reductions - 25% Internal & 50% External
Total Phosphorus (mg L^{-1})	0.276	0.268
Total Nitrogen (mg L^{-1})	0.786	0.658
Conservative nutrient (Nitrogen, mg L^{-1})	0.052	0.041
Chlorophyll-a (Fg L^{-1})	17.180	17.060
Secchi disk depth (m)	1.710	2.040
Carlson's TSI Phosphorus	85.200	84.770
Carlson's TSI Chlorophyll-a	58.500	58.430
Carlson's TSI Secchi	52.250	49.750

Table 23. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external load and a 50 percent reduction in internally available total phosphorus and total nitrogen

Variable	Reduction -50% Observed	Reductions - 50% Internal & 50% External
Total Phosphorus (mg L^{-1})	0.276	0.260
Total Nitrogen (mg L^{-1})	0.786	0.655
Conservative nutrient (Nitrogen, mg L^{-1})	0.052	0.042
Chlorophyll-a (Fg L^{-1})	17.18	16.93
Secchi disk depth (m)	1.71	2.05
Carlson's TSI Phosphorus	85.20	84.32
Carlson's TSI Chlorophyll-a	58.50	58.35
Carlson's TSI Secchi	52.25	49.67

Table 24. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external load and a 75 percent reduction in internally available total phosphorus and total nitrogen

Variable	Reduction -50% Observed	Reductions - 75% Internal & 50% External
Total Phosphorus (mg L^{-1})	0.276	0.252
Total Nitrogen (mg L^{-1})	0.786	0.652
Conservative nutrient (Nitrogen, mg L^{-1})	0.052	0.041
Chlorophyll-a (Fg L^{-1})	17.18	16.80
Secchi disk depth (m)	1.71	2.06
Carlson's TSI Phosphorus	85.20	83.86
Carlson's TSI Chlorophyll-a	58.50	58.28
Carlson's TSI Secchi	52.25	49.60

Table 25. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external load and a 90 percent reduction in internally available total phosphorus and total nitrogen

Variable	Reduction -50% Observed	Reductions - 90% Internal & 50% External
Total Phosphorus (mg L^{-1})	0.276	0.247
Total Nitrogen (mg L^{-1})	0.786	0.650
Conservative nutrient (Nitrogen, mg L^{-1})	0.052	0.041
Chlorophyll-a (Fg L^{-1})	17.18	16.71
Secchi disk depth (m)	1.71	2.07
Carlson's TSI Phosphorus	85.20	83.57
Carlson's TSI Chlorophyll-a	58.50	58.22
Carlson's TSI Secchi	52.25	49.54

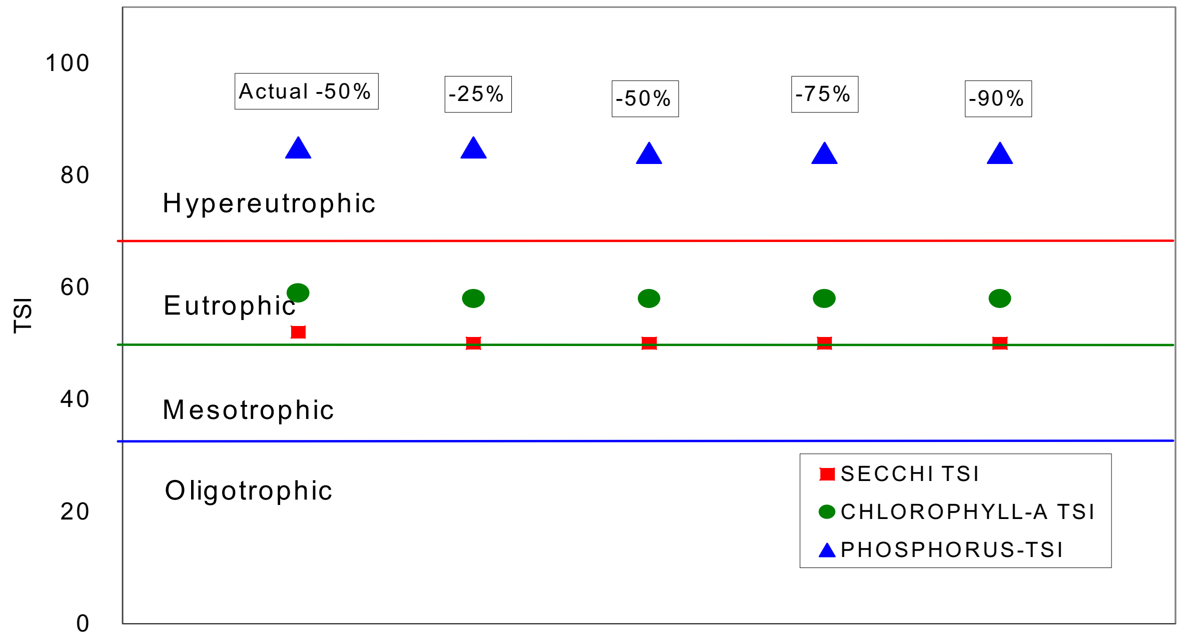


Figure 49. Pheasant Lake predicted trophic response to reductions in external nitrogen and phosphorus load of 50 percent and internally available nitrogen and phosphorus of 25, 50, 75 and 90 percent

4.0 LAND USE ASSESSMENT AND AGNPS MODEL RESULTS

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a distributed multi-parameter model developed by the Agricultural Research Service. It predicts soil erosion and nutrient transport and loading from agricultural watersheds for real or hypothetical storms (i.e., it is an event-based model). Erosion modeling predictions are based on the Universal Soil Loss Equation.

In use, a watershed of interest is subdivided into a grid of squares. A total of 22 coefficients can be attributed to these squares. The coefficients describe the condition, physical characteristics, management practice and rainfall for each square. The AGNPS model then predicts the nonpoint source pollution and hydraulic discharge for each square as a function of time.

4.1 Objective

The basic objective of utilizing AGNPS modeling was to identify areas that contribute the most nonpoint source pollution. Specific objectives included (1) evaluation of nonpoint source pollution yields within discrete subwatersheds, (2) defining the hot spots within these subwatersheds and (3) evaluating potential impacts from livestock concentration areas individual and in total.

4.2 Methodology

The 3.65 version of the AGNPS model was used in conjunction with a 2001 land use assessment. A 25-year precipitation event of 4 inches in 24 hours was chosen for evaluation purposes. Model cell size was 40 acres. A total of 1,524 cells, or 60,940 acres, was assessed.

The Pheasant Lake watershed was subdivided into four discrete subwatersheds. The end points for the four subwatersheds are located at roughly the same spots as with the water quality monitoring stations for Elm River (385083) Northwest Tributary (385082), West Northwest Tributary (385081) and West Tributary (385080) (Figure 50).

Fifteen coefficients were used for the Pheasant Lake watershed AGNPS modeling. They are: receiving cell, aspect, SCS curve, slope, slope shape, slope length, Mannings coefficient, cropping factor, practice factor, surface condition constant, soil texture, fertilization level, point source indicator, chemical oxygen demand factor and channel indicator. The AGNPS model was then run to calculate nutrient and sediment output, feedlot inventories, runoff and erosion rates.

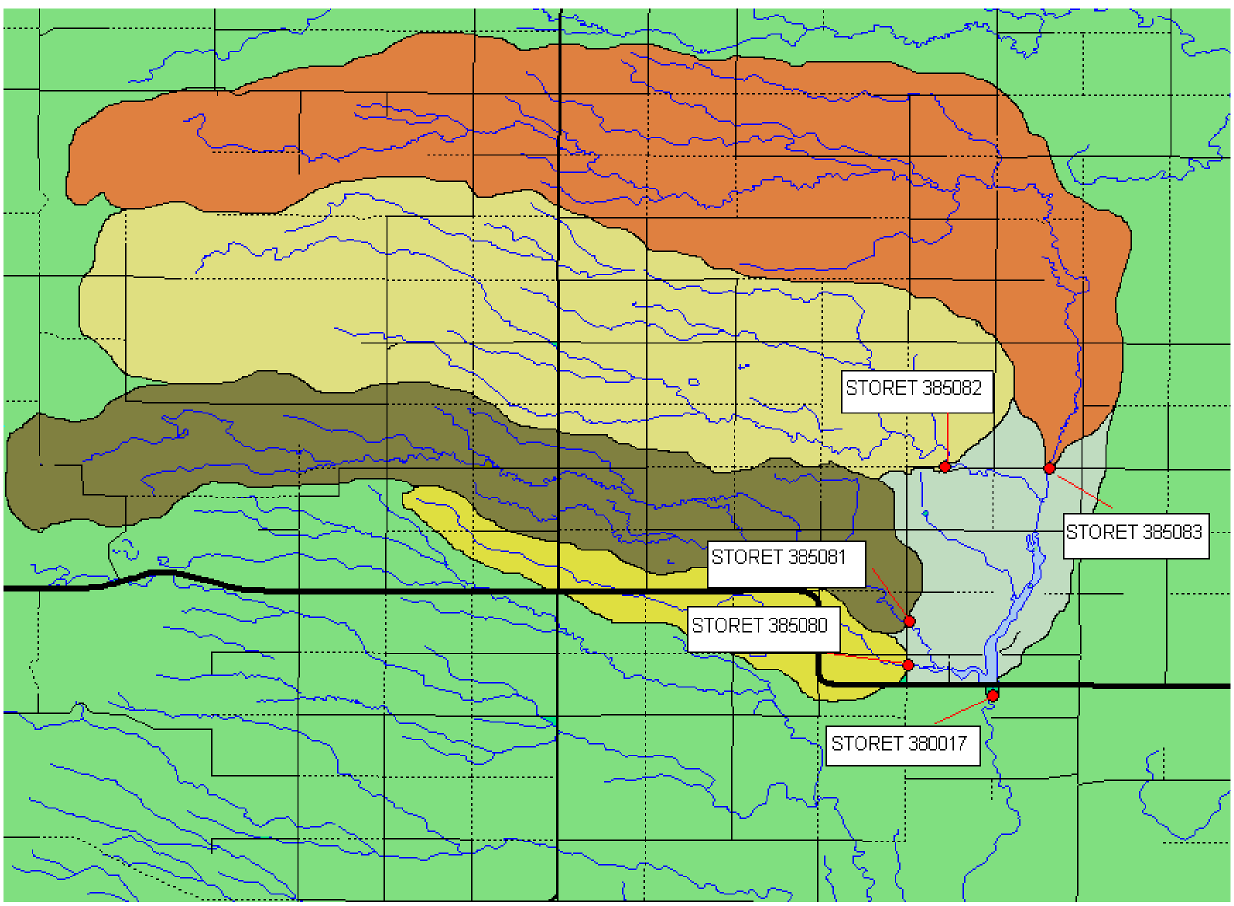


Figure 50. Approximate area of the AGNPS subwatersheds and water quality monitoring stations

4.3 Land Use Results

Other than the low density urban development around Pheasant Lake, the land use survey required for AGNPS data input files identified that 100 percent of the watershed is in agricultural production or in support of agricultural production such as farmsteads and farm-to-market roads. The principal uses included pasture, row crops, small grain, alfalfa/hay, conservation reserve program (CRP), fallow ground and wetlands or streams (Table 26). Additionally, the land survey identified 33 farmsteads and 15 concentrated livestock holding areas (Table 27).

Table 26. Land use in the Pheasant Lake watershed

Subwatershed	Land Use	Acres	Subwatershed	Land Use	Acres
Elm River	Pasture	8,440	Northwest	Pasture	4,480
	Row Crop	4,880		Row Crop	4,680
	Small grains	4,640		Small Grains	4,320
	Alfalfa/Hay	2,480		Alfalfa/Hay	1,640
	CRP	3,000		CRP	1,640
	Fallow	280		Fallow	760
	Water	80		Water	80
West Northwest	Pasture	7,840	West	Pasture	680
	Row Crop	1,480		Row Crop	1,480
	Small grains	1,680		Small Grains	1,680
	Alfalfa/Hay	560		Alfalfa/Hay	560
	CRP	680		CRP	480
	Fallow	280		Fallow	40
	Water	0		Water	0

Table 27. Farmsteads and concentrated livestock feeding areas in the Pheasant Lake watershed

Subwatershed	Farmsteads	Feedlots	Lake Cabins
Immediate Watershed	4	0	70
Elm River	10	6	0
Northwest	4	4	0
West Northwest	7	5	0
West	1	0	0
Totals	26	15	70

4.4 AGNPS Modeled Area-Weighted Yield Estimates

The AGNPS model subwatershed are located at approximately the same spots as the water quality monitoring stations Elm River (385083), Northwest Tributary (385082), West Northwest Tributary (385081) and West Tributary (385080). The AGNPS modeling results per subwatershed are broken down into: (1) acres, (2) hydraulic delivery in inches per acre, (3) peak runoff rate in cubic feet per second, (4) area-weighted nitrogen in sediment delivery, (5) area-weighted dissolved nitrogen delivery, (6) soluble nitrogen concentration in runoff in mg L^{-1}, (7) area-weighted phosphorus delivery, (8) area-weighted dissolved phosphorus delivery and (9) dissolved phosphorus concentration in runoff in mg L^{-1}.

Modeled peak runoff in cubic feet per second (cfs) ranged from a low of 1,766.19 on the West subwatershed to a high of 5,907.47 on the Elm River subwatershed. The modeled inches of runoff for the subwatersheds at Elm River, Northwest and West were lower (1.78 to 1.81 inches) than the modeled runoff for the West Northwest subwatershed of 1.90 inches. In general, the nutrient and sediment delivery predictions were less from the West subwatershed, slightly elevated on the Elm River and Northwest subwatershed, and noticeablly higher from the West Northwest subwatershed (Table 28), (Figures 30 through 32).

Table 28. AGNPS model upland delivery estimates for the Pheasant Lake subwatersheds based on a 25-year rainfall event of 4 inches in 24 hours

Subwatershed Name	Acres	Runoff	CFS
Elm River	23,880	1.80	5,907.42
Northwest	17,360	1.78	4,293.05
West Northwest	14,720	1.90	3,705.78
West	4,920	1.81	1,766.19

Subwatershed Name	lbs/acre N in Sediment	lbs/acre N in Runoff	mg L^{-1} Soluble N in Runoff
Elm River	1.52	1.21	2.97
Northwest	1.68	1.12	2.78
West Northwest	2.46	1.32	3.07
West	1.20	1.41	3.46

Subwatershed Name	lbs/acre P in Sediment	lbs/acre P in Runoff	mg L^{-1} Soluble P in Runoff
Elm River	0.76	0.22	0.55
Northwest	0.84	0.20	0.49
West Northwest	1.23	0.25	0.58
West	0.60	0.26	0.64

Subwatershed Name	tons/acre Soil Erosion	tons/acre Soil Delivery	mg L^{-1} Conc. in Runoff
Elm River	4.03	0.49	2,389.30
Northwest	5.11	0.56	2,755.52
West Northwest	8.04	0.89	4,153.67
West	1.88	0.25	1,219.18

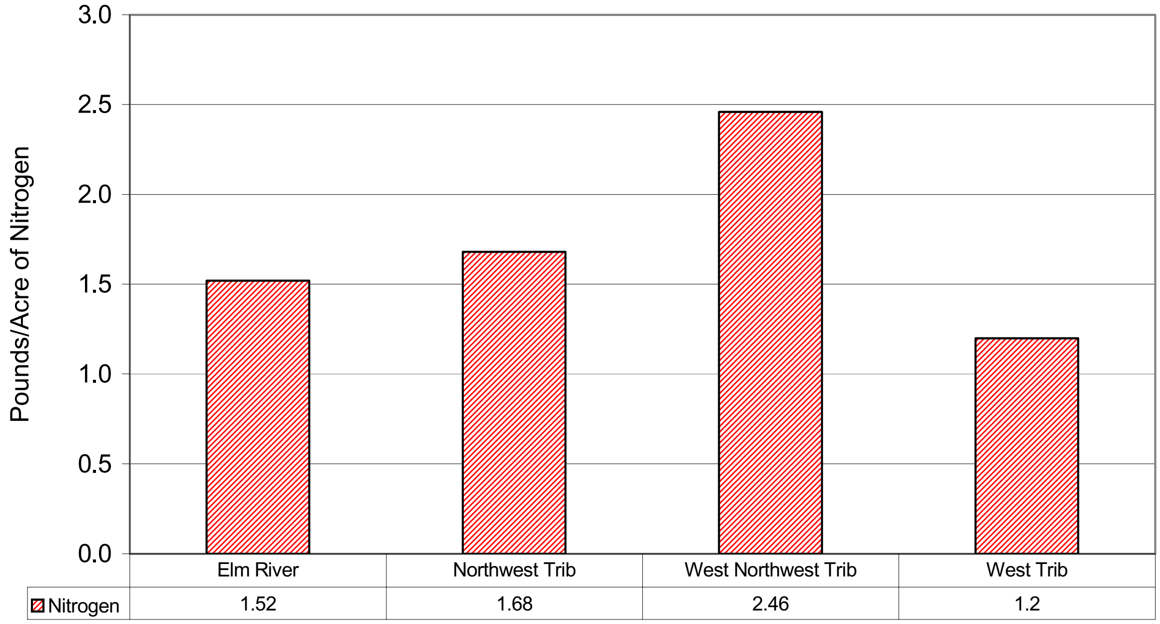


Figure 51. Pounds per acre of total nitrogen in eroded sediment from a 24-hour, 4-inch rain event on the upstream subwatershed of Pheasant Lake

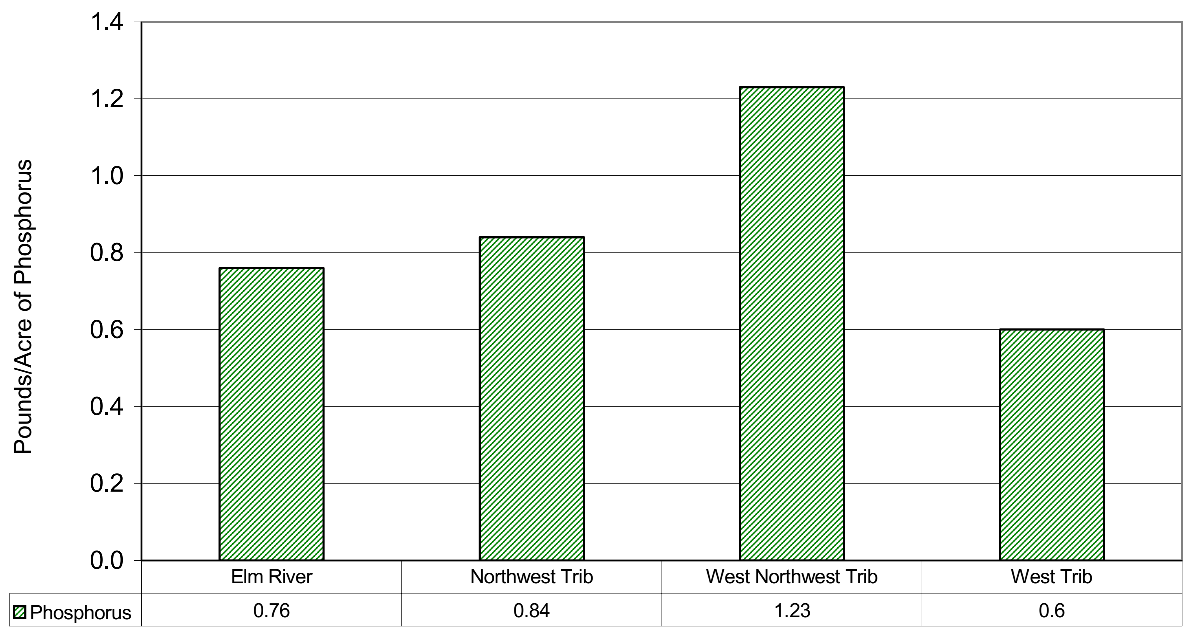


Figure 52. Pounds per acre of total phosphorus in eroded sediment from a 24-hour, 4-inch rain event on the upstream subwatersheds of Pheasant Lake

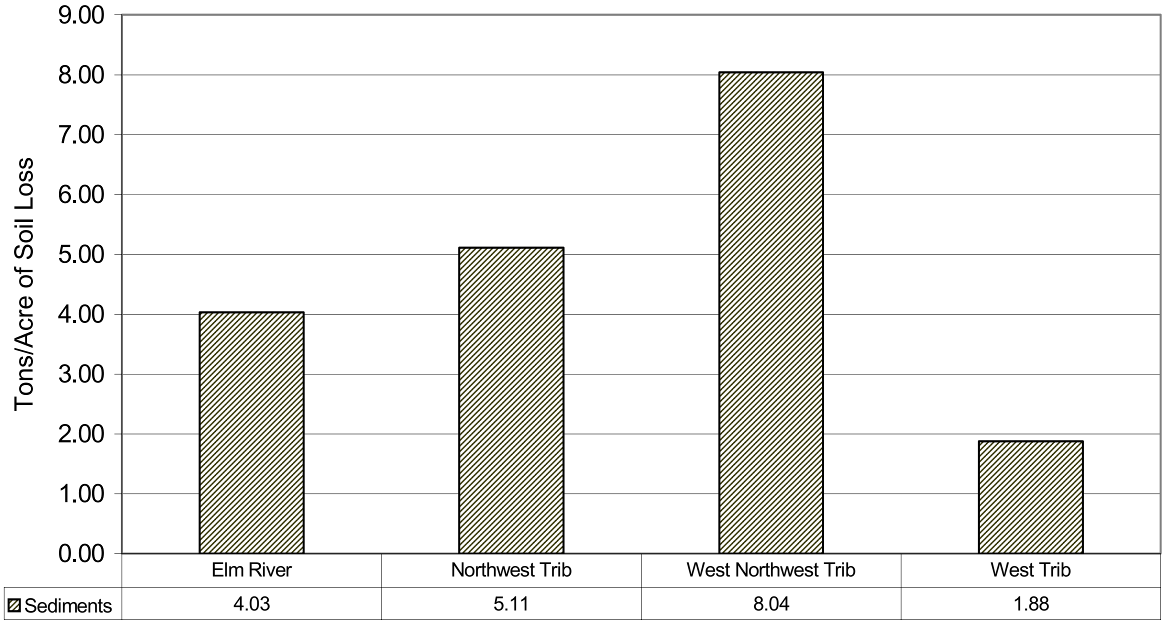


Figure 53. Tons per acre of eroded sediments from a 24-hour, 4 inch rain event on the upstream subwatersheds of Pheasant Lake

4.5 AGNPS Model Critical Area Identification

Critical area per subwatershed was identified by modeling the potential for erosion and nutrient losses. The precipitation event entered into the model was a 4-inch, 24-hour rain event. Critical area was identified for sediment, nitrogen and phosphorus yields. The critical area per subwatershed was divided into three groups for soil loss (critical, highly critical and extremely critical) and two groups for nitrogen and phosphorus (critical and highly critical).

For sediment loss, the critical area was defined as the percentage of acres per subwatershed with a predicted soil loss of 5 tons per acre and above, highly critical as 7 tons per acre and above and extremely critical as 10 tons per acre and above. For nitrogen; critical area was defined as the percentage of the subwatershed with predicted nitrogen yields in excess of 3 pounds per acre and highly critical as the percentage with yields of 5 pounds per acre or more. Highly critical areas for phosphorus were defined as the percentage of subwatershed with predicted phosphorus yields in excess of 1.5 pounds per acre and above, and highly critical as the percentage of the subwatershed with phosphorus yields of 3 pounds per acre or more.

In general the subwatersheds critical area, based on soil loss, was consistent throughout the full range of critical, highly critical and extremely critical gradations. The AGNPS model predicted that the West Northwest subwatershed had the largest percentage of area with soil loss in excess of 5, 7 and 10 tons per acre followed in descending order of percent critical area by the Northwest, Elm River and West subwatersheds (Table 29), (Figures 54 through 56).

Table 29. AGNPS model predicted soil loss above 5, 7 and 10 tons per acre during a 25-year rain event of 4 inches in 24 hours

Subwatershed Name	Acres	Acres >5 tons	% >5 tons	Acres >7 tons	% >7 tons	Acres >10 tons	% >10 tons
Elm River	23,880	3,440	14.41	2,520	10.55	1,720	7.20
Northwest	17,360	8,600	20.51	2,280	13.13	2,000	11.52
West Northwest	14,720	5,440	36.96	2,880	19.57	2,600	17.66
West	4,920	760	8.94	320	6.50	80	1.63

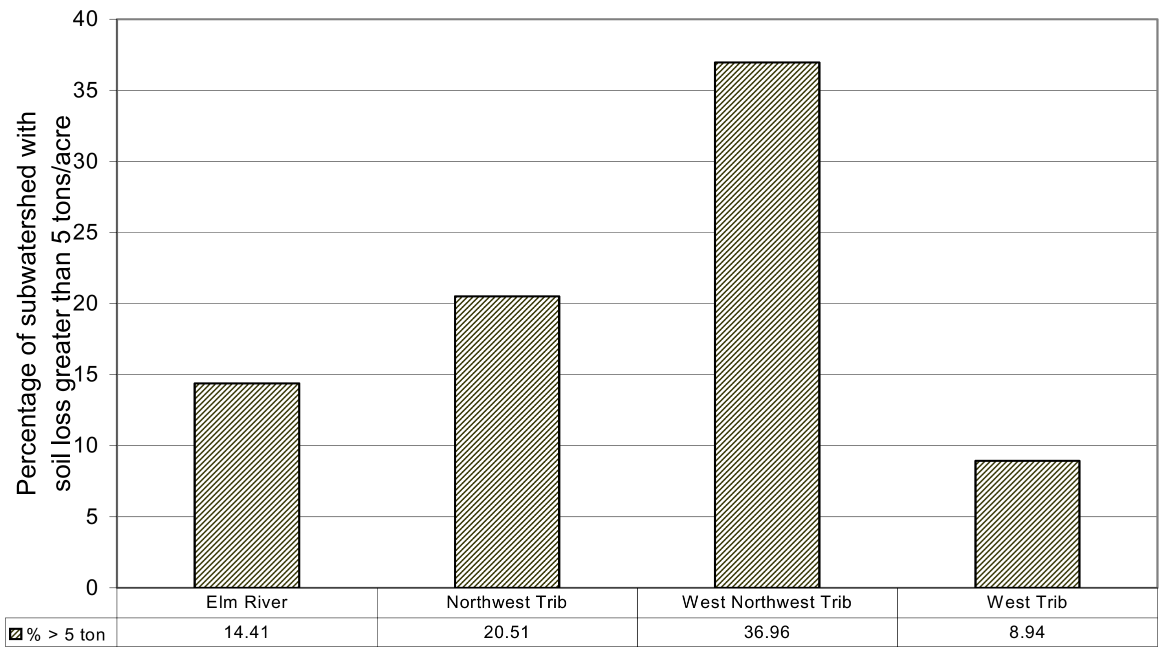
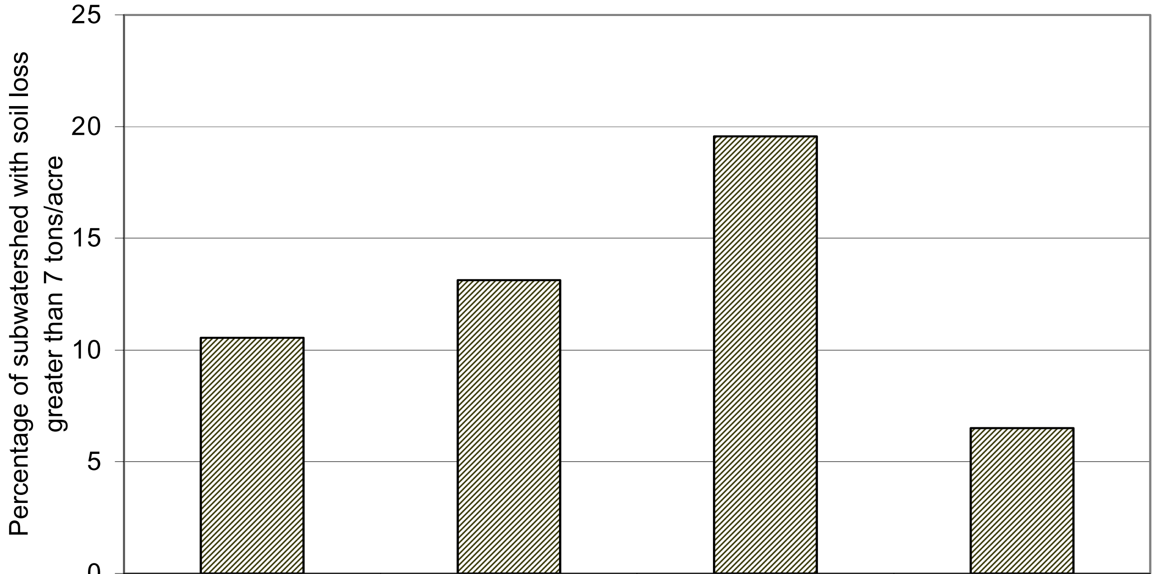
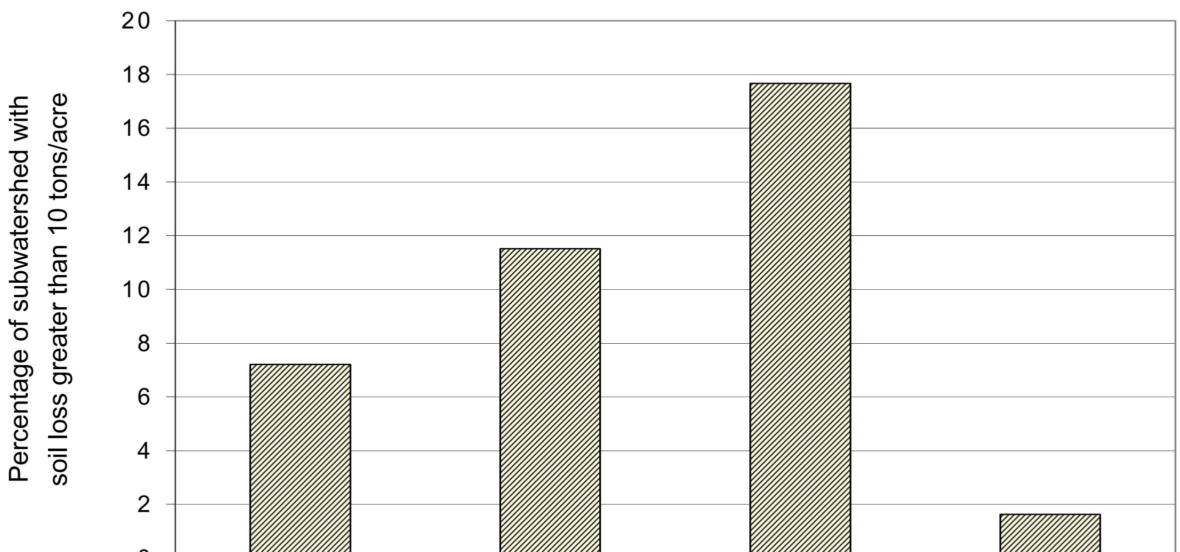


Figure 54. Percentage of subwatersheds with AGNPS model predicted soil loss in excess of 5 tons per acre or greater from a single 4-inch, 24-hour rain event (critical)



	Elm River	Northwest Trib	West Northwest Trib	West Trib
% > 7 ton	10.55	13.13	19.57	6.50

Figure 55. Percentage of subwatersheds with AGNPS model predicted soil loss in excess of 7 tons per acre from a single 4-inch, 24-hour rain event (highly critical)



	Elm River	Northwest Trib	West Northwest Trib	West Trib
% > 10 ton	7.20	11.52	17.66	1.63

Figure 56. Percentage of subwatersheds with AGNPS model predicted soil loss in excess of 10 tons per acre from a single 4-inch,24-hour rain event (extremely critical)

The percentage of subwatersheds with potential for nitrogen loss of 3 pounds per acre and above from a single 4-inch 24-hour rain event ranged from a low of 15.45 percent on the West to a high of 79.89 percent on the West Northwest subwatershed. The percentage of subwatersheds with a potential for nitrogen loss of 5 pounds per acre or above ranged from a low of 3.25 again on the West to a high of 10.83 percent on the Elm River subwatershed (Table 30) (Figures 57 & 58).

Table 30. AGNPS model predicted nitrogen loss above 3 and 5 pounds per acre during a 25-year rain event of 4 inches in 24 hours.

Subwatershed Name	Acres	Acres >3 lbs/acre	% >3 lbs/acre	Acres >5 lbs/acre	% > 5 lbs/acre
Elm River	23,880	10,880	45.56	5,080	21.27
Northwest	17,360	8,600	49.54	1,880	10.83
West Northwest	14,720	11,760	79.89	6,640	45.11
West	4,920	760	15.45	320	3.25

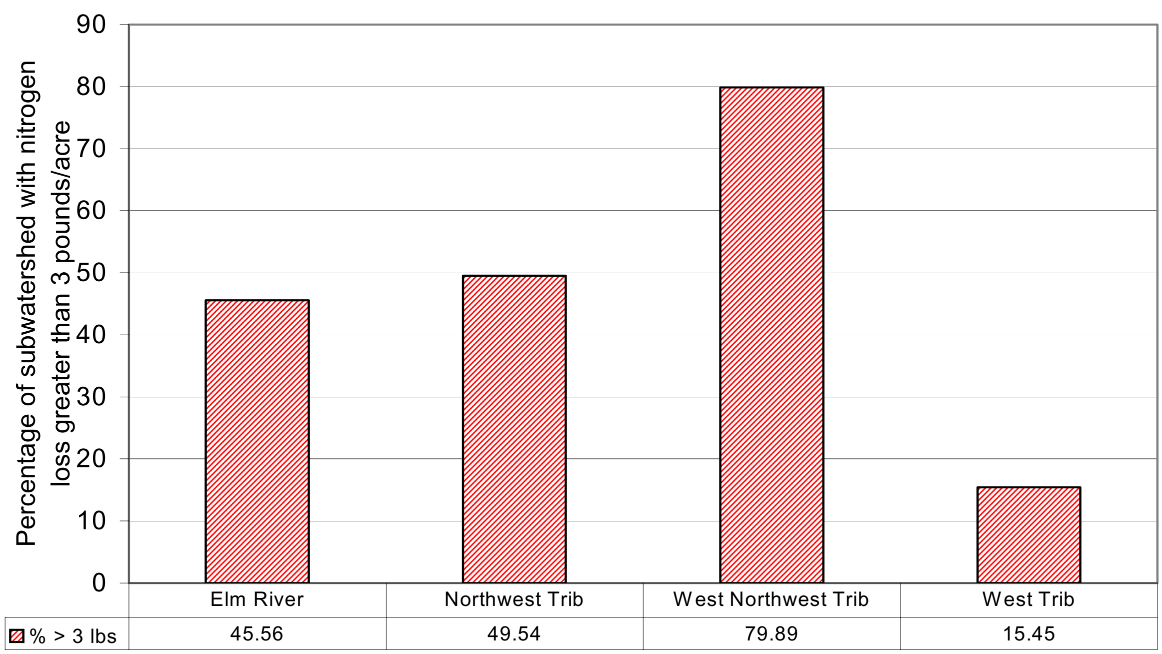


Figure 57. Percentage of subwatersheds with AGNPS model predicted nitrogen loss in excess of 3 pounds per acre from a 4-inch, 24-hour rain event (critical)

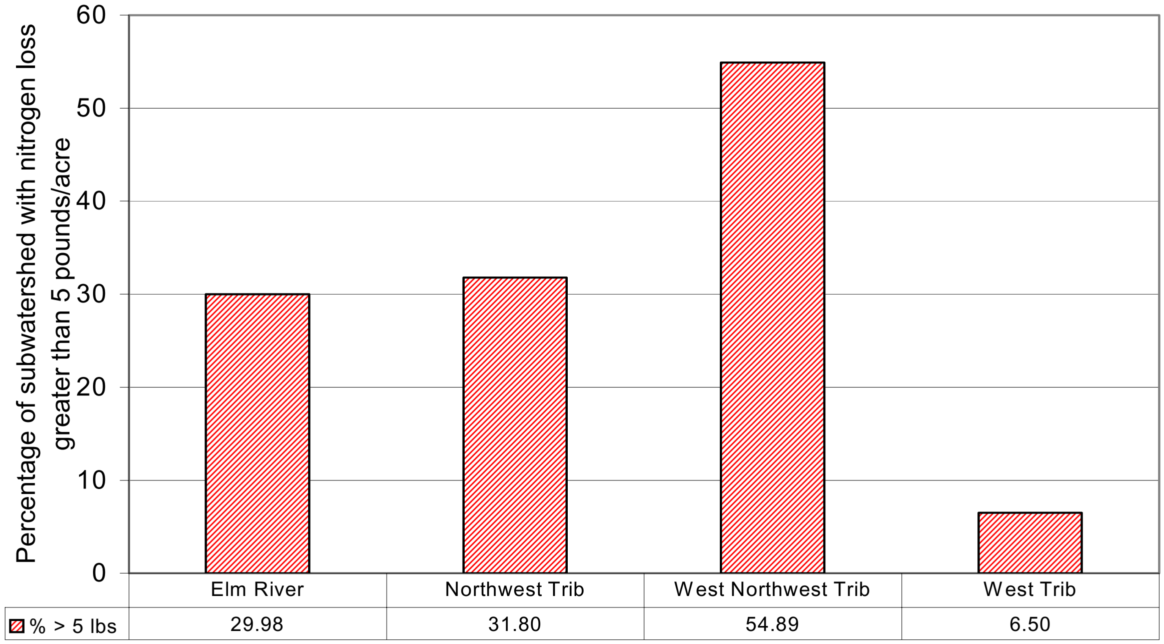


Figure 58. Percentage of subwatersheds with AGNPS model predicted nitrogen loss in excess of 5 pounds per acre from a single 4-inch, 24-hour rain event (highly critical)

The percentage of subwatersheds with potential for phosphorus loss of 1.5 pounds per acre and above from a single 4-inch, 24-hour rain event ranged from a low of 13.82 percent on the West subwatershed to a high of 67.12 percent on the West Northwest subwatershed. The percentage of subwatersheds with a potential for phosphorus loss of 3 pounds per acre or above ranged from a low of 3.25 percent on the West subwatershed to a high of 45.11 percent on the West Northwest subwatershed (Table 31), (Figures 59 and 60).

Table 31. AGNPS model predicted phosphorus loss above 1.5 and 3 pounds per acre during a 25-year rain event of 4 inches in 24 hours

Subwatershed Name	Acres	Acres >1.5 lbs/acre	% >1.5 lbs/acre	Acres >3 lbs/acre	% >3 lbs/acre
Elm River	23,880	13,080	54.77	5,080	21.27
Northwest Trib	17,360	7,880	45.39	1,880	10.83
West Northwest Trib	14,720	9,880	67.12	6,640	45.11
West Trib	4,920	680	13.82	160	3.25

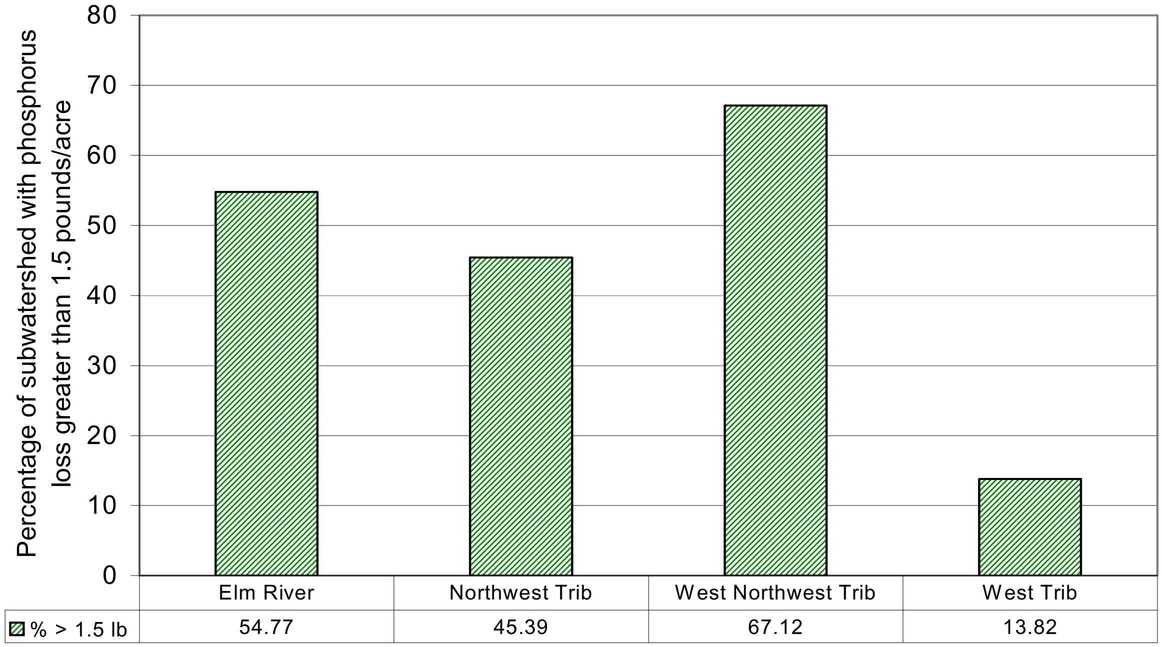


Figure 59. Percentage of subwatershed with AGNPS model predicted phosphorus loss in excess of 1.5 pounds per acre from a single 4-inch, 24-hour rain event (critical)

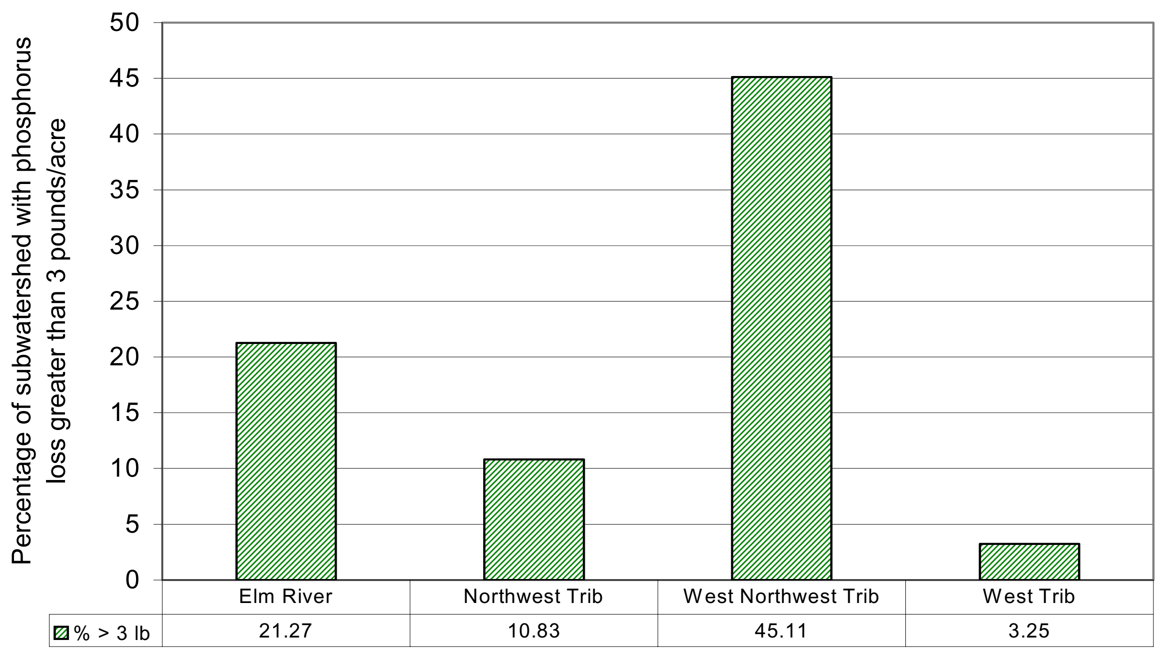


Figure 60. Percentage of subwatershed with AGNPS model predicted phosphorus loss in excess of 3 pounds per acre from a single 4-inch, 24-hour rain event (highly critical)

4.6 Feedlot Condition

Feedlot density and condition was evaluated using the AGNPS model in the Pheasant Lake watershed. The AGNPS model evaluated feedlot condition within the subwatersheds through a ranking system based on a scale of zero to 100, where zero represents no increases in the concentration or delivery of chemical oxygen demand, phosphorus or nitrogen in feedlot runoff, and 100 represents complete saturation of these analytes.

In all, 15 feedlot operations were identified. The feedlot-to-acre ratio was 0.03 for the Elm River, Northwest and West Northwest subwatersheds and 0.0 (zero) for the West subwatershed. Of the 15 feedlots, 12 had a ranking of 40 or above and eight had a ranking of 50 or above. Sixty-seven percent of the feedlots in the Elm River subwatershed had a ranking above 50 followed in descending order by the Northwest subwatershed at 60 percent and the West Northwest subwatershed at 25 percent (Table 32), (Figures 61 through 63).

Table 32. AGNPS model feedlot scores and feedlot per acre density

Subwatershed Name	Acres	Number Feedlots	Score >30	Score >40	Score >50	Percent > 50	Feedlot/ Acre
Elm River	23,880	6	6	6	4	67	0.03
Northwest Trib	17,360	5	5	5	3	60	0.03
West Northwest Trib	14,720	4	1	1	1	25	0.03
West Trib	4,920	0	0	0	0	0	0.00

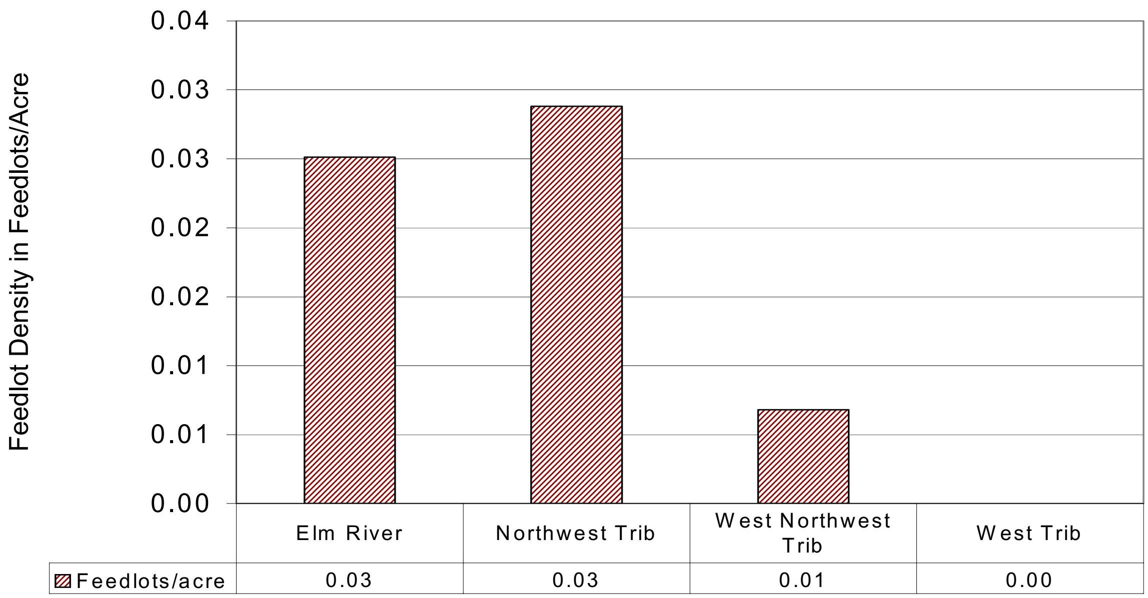
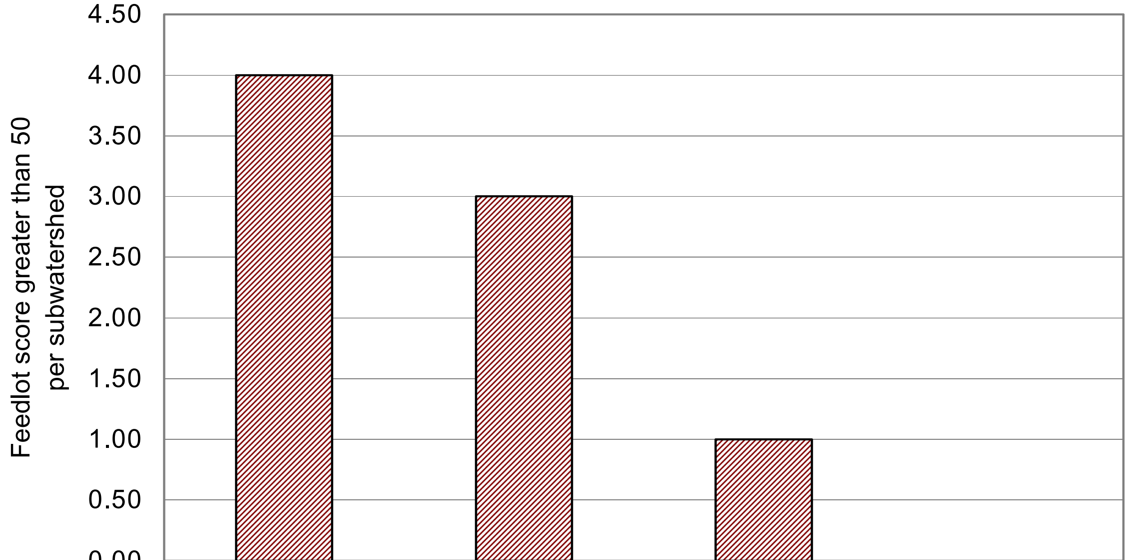
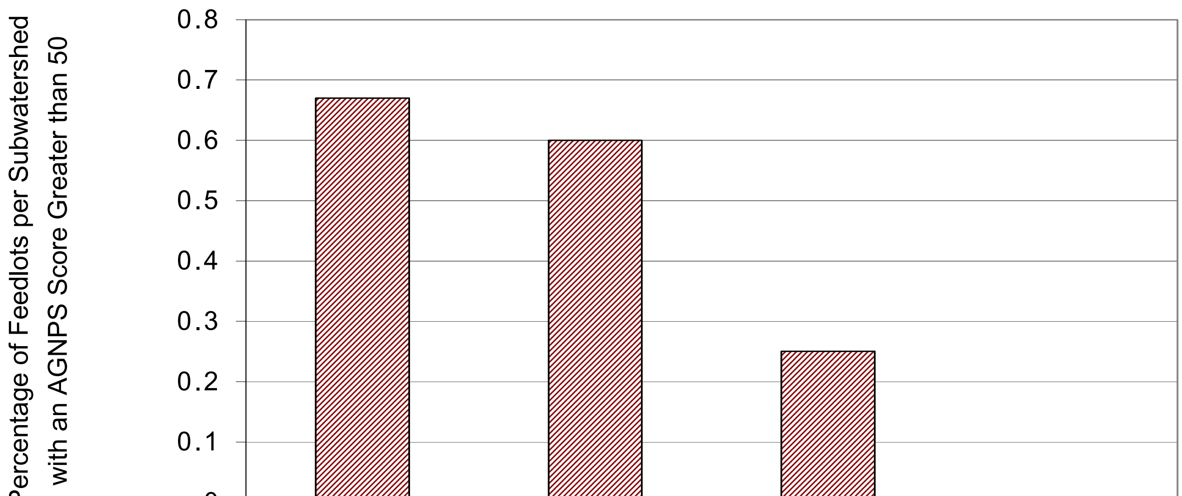


Figure 61. Subwatershed feedlot density in feedlots per acre



	Elm River	Northwest Trib	West Northwest Trib	West Trib
>$50	4	3	1	0

Figure 62. Number of feedlots per subwatershed with an AGNPS model score that equals or exceeds 50



	Elm River	Northwest Trib	West Northwest Trib	West Trib
Percent > 50	0.67	0.6	0.25	0

Figure 63. Percentage of feedlots per subwatershed that equal or exceed an AGNPS score of 50

4.7 Pasture and Rangeland Condition

Range and pasture lands were assessed using a rapid visual assessment protocol that quickly ranked range condition into the three categories of poor, fair and good. The survey identified 21,140 acres of pasture and rangeland in the four subwatersheds, of which 17,600 acres, or 83 percent, ranked poor. Of the four subwatersheds, the West had the smallest percentage of rangeland in poor condition at 58.3 percent, followed in increasing percentages by the Elm River at 77.67 percent, the West Northwest at 87.15 percent and the Northwest at 89.29 percent (Table 33), (Figures 64 and 65).

Table 33. Rangeland and rangeland in poor condition by subwatershed

Subwatershed Name	Acres	Acres Poor	%Acre Poor
Elm River	45,440	2,880	4.56
Northwest	63,200	2,720	5.99
West Northwest	69,440	6,080	8.76
West	108,480	3,680	3.39

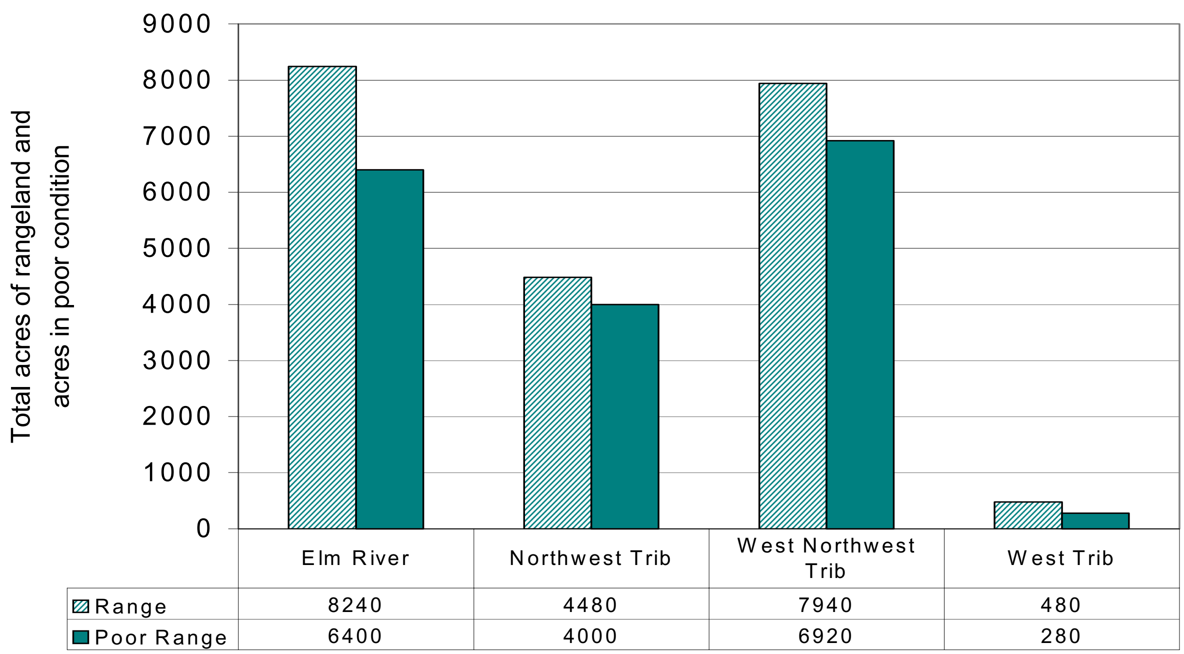


Figure 64. Acres of rangeland and rangeland in poor condition by subwatershed

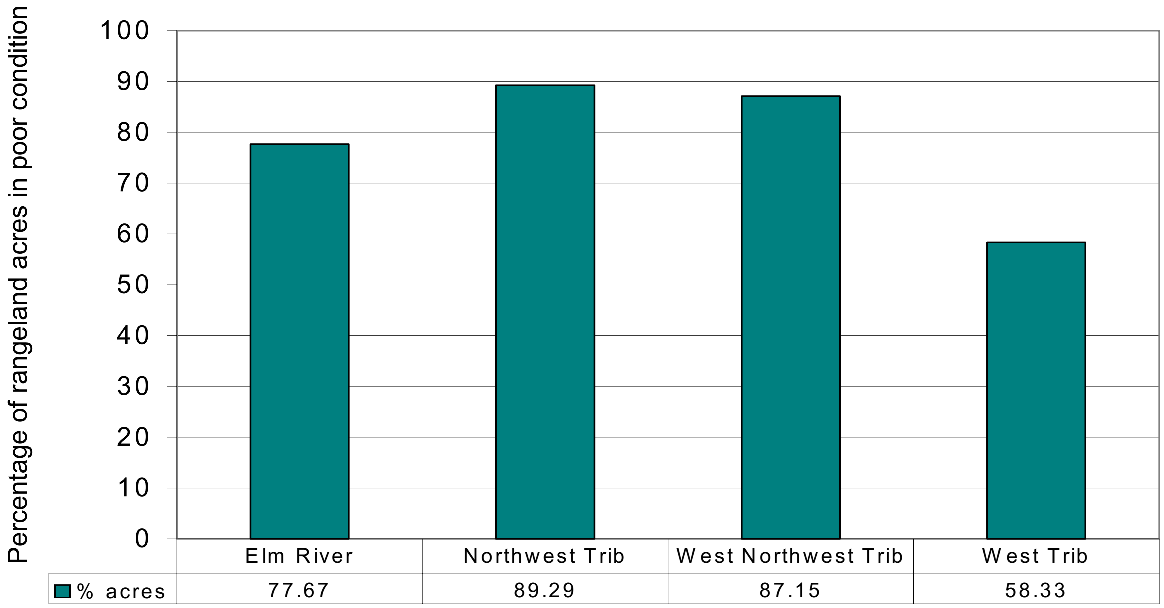


Figure 65. Percentage of rangeland acres in poor condition by subwatershed

5.0 LINKAGE BETWEEN LAND USE AND WATER QUALITY AND QUANTITY DATA

An attempt was made to identity which land uses and or conditions were driving the water quality and annual loads of pollutants within the Pheasant Lake watershed by comparing the AGNPS model-predicted deliveries and concentrations to the measured load and concentrations. While this appeared logical, many factors such as the flushing of high concentrations of total suspended solids in the form of algae from wetlands and nutrients stored in stream pools after periods of low or no flow conditions prevented the development of a relationship between modeled and actual pollution concentrations. However, the AGNPS model-identified percentage of critical acres per subwatershed does appear to show a useful relationship with the annual mass loading estimates.

5.1 Linkage Between Percent Critical Area and Mass Loading Analysis

The relationship between the percentage of acres for critical nitrogen loss, identified by the number of acres with AGNPS model-predicted loss of 3 pounds per acre or greater, correlated well to the mass load of total nitrogen with an R-Square of 0.83. This connection between percentage of critical area per subwatershed appears supported by the other pollutants of concern (i. e., nitrate + nitrite as nitrogen, total phosphorus and total suspended solids). The comparison of the percentage of critical area for nitrogen loss, based on an AGNPS model-predicted 3 pounds per acre loss, to nitrate + nitrite mass loads yielded an R-Squared of 0.7818. The percentage of critical area for phosphorus loss, based on a AGNPS model predicted 1.5 pounds per acre loss, to total phosphorus mass load yielded an R-Squared of 0.6239. The percentage of critical area for soil loss, based on an AGNPS model-prediction of 5 pounds per acre or greater, to the mass load of total suspended solids yielded an R-Square of 0.5142 (Figures 66 through 69).

It is hypothesized that relationship between critical area and phosphorus is weakened and nitrogen strengthened during the low-flow and intermittent flow periods. During these time periods, total phosphorus concentrations increased not because of additional external loadings but because of internal cycling within the streams. As the streams and interconnected wetlands heated they bloomed and became nitrogen-limited. During this period, phosphorus was readily available, but nitrogen, other than in the organic form, was nearly nonexistent. This provided a ready surplus of phosphorus not related to overland yields that was flushed out with each increase in flow, elevating the loadings above what was being washed in. Inversely, there is an absence of inorganic nitrogen available during these periods so that, during these same events, any captured while sampling was a direct result of active runoff. This apparent effect on phosphorus can be readily seen in the total phosphorus concentration temporal distribution and hydraulic loading graphs in Figures 11, 15, 19, 23 and 27.

Related to this process is the weakening of the relationship between total suspended solid mass load and AGNPS model-predicted soil loss due to biological productivity in the interconnected wetlands and stream pools. During zero-flow and low-flow conditions, the interconnected wetlands and pools bloomed with algae and aquatic plants. When a storm event pushed this water through, plant parts and aquatic organisms were flushed through the system increasing the total suspended solid mass load unrelated to upland erosion. This type of effect on total suspended solid load can be seen in the total suspended solids concentrations, temporal distribution and hydraulic loading graphs in Figures 12, 16, 20, 24 and 28.

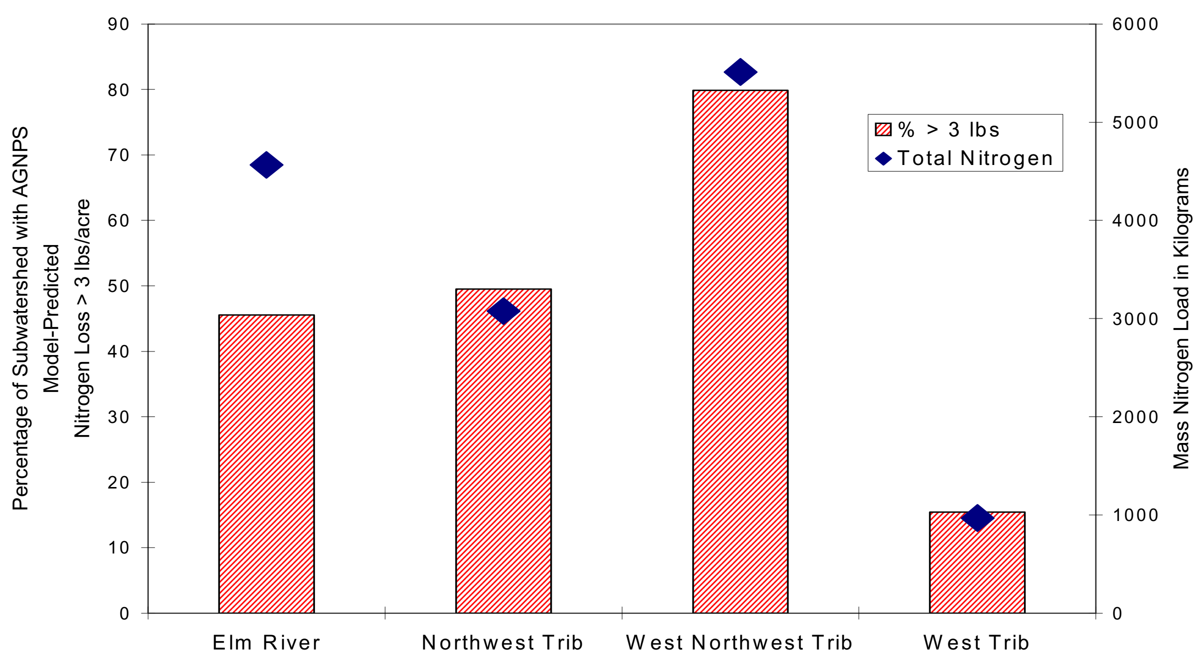


Figure 66. Graphic relationship between percentage of critical area for nitrogen loss of greater than 3 pounds per acre and mass load of total nitrogen in Kg (R-Square 0.8381)

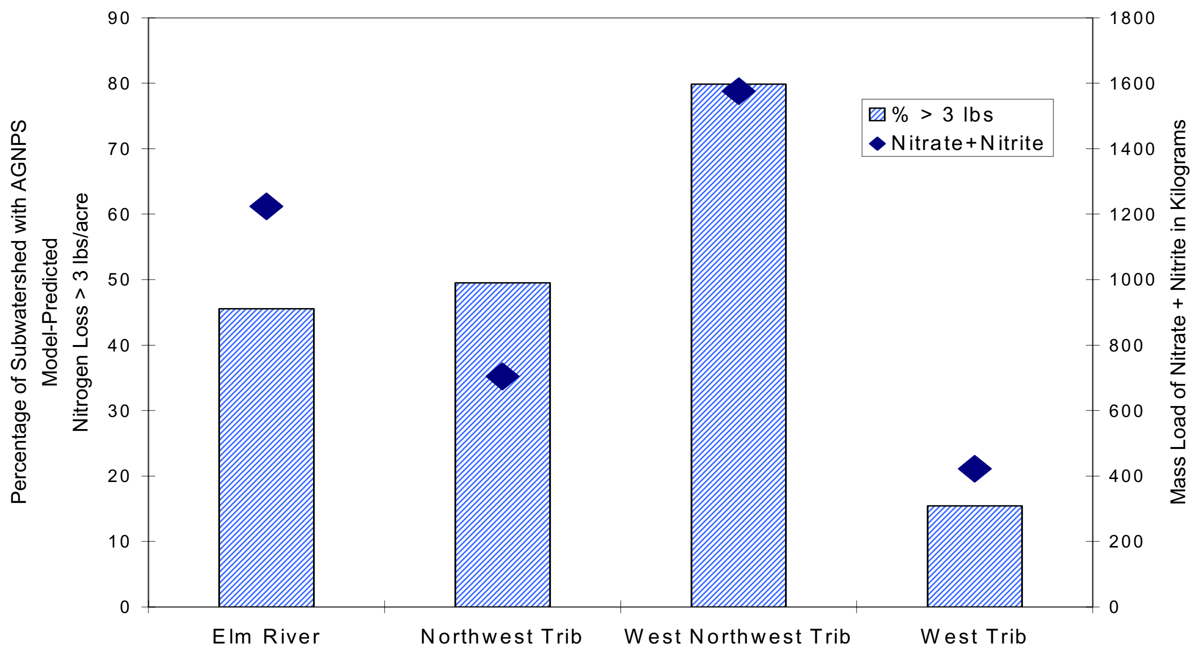


Figure 67. Graphic relationship between percentage of critical area for nitrogen loss of greater than 3 pounds per and mass load of nitrate + nitrite as nitrogen in Kg (R-Square 0.7818)

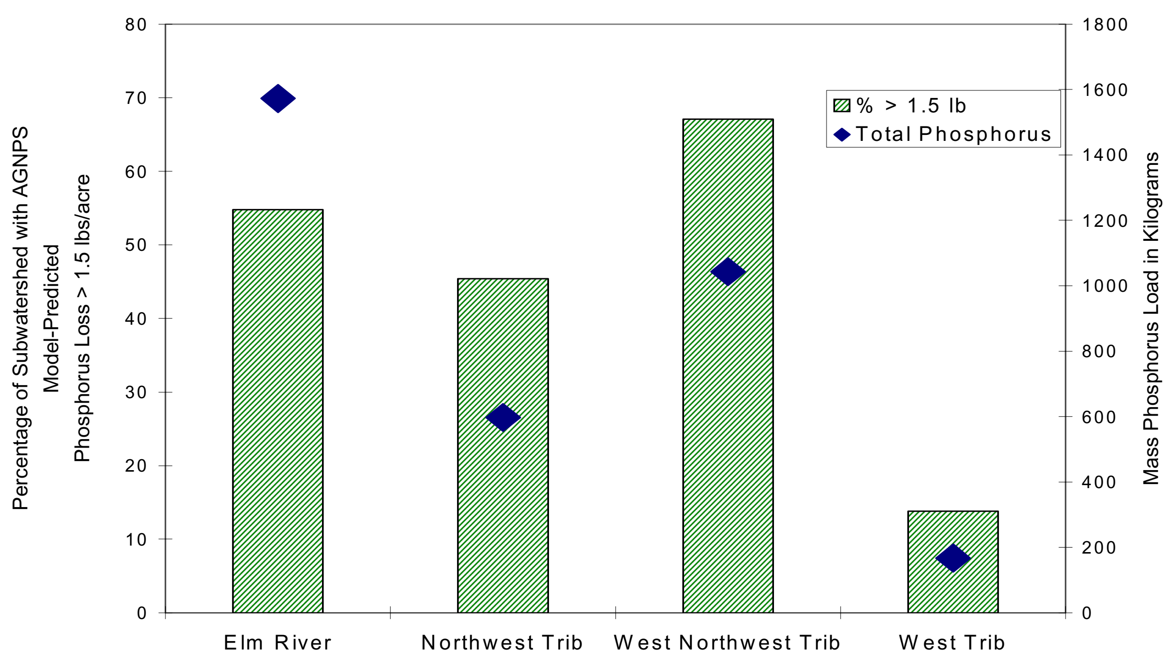


Figure 68. Graphic relationship between percentage of critical area for phosphorus loss of greater than 1.5 pounds per acre and mass load of total phosphorus in Kg (R-Square 0.6239)

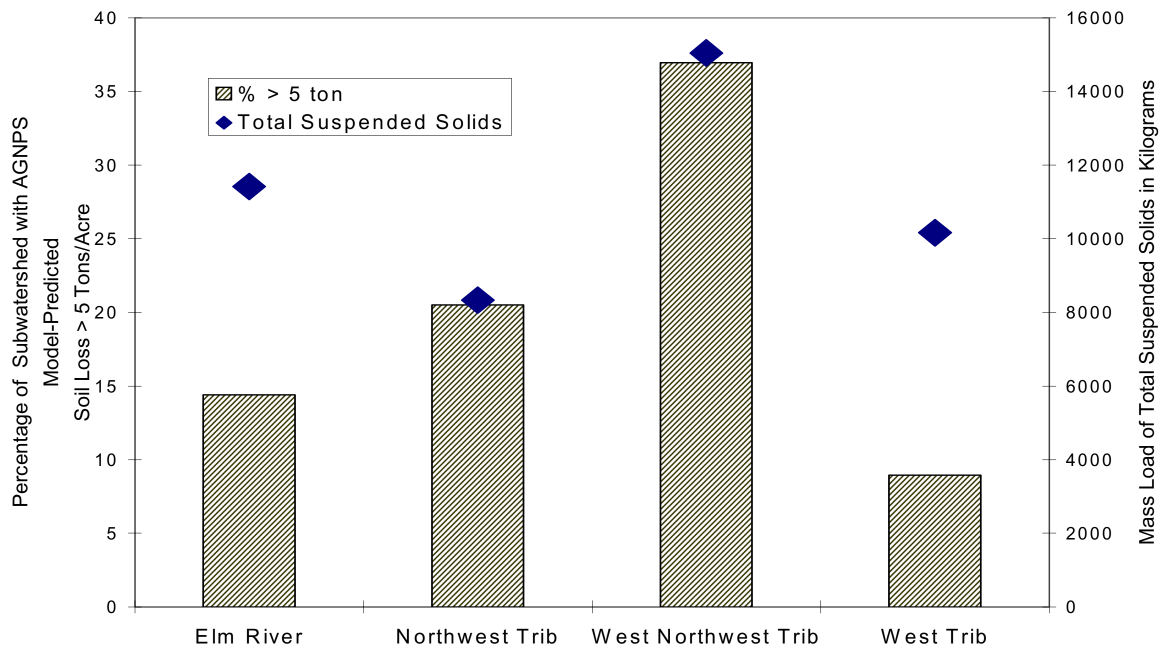


Figure 69. Graphic relationship between percentage of area critical area for soil loss of greater than 5 tons per acre and mass load of total suspended solids in Kg (R-Square 0.5142)

6.0 TROPHIC RESPONSE AND POLLUTION LOAD TARGET DEVELOPMENT

The trophic response and pollution load targets are set to achieve the goal as defined in the Quality Assurance Project Plan for the Pheasant Lake TMDL.The primary goal of this project is to develop a nutrient and sediment total maximum daily load (TMDL) for Pheasant Lake which, if implemented, will improve the lake's trophic status, thereby improving and maintaining its beneficial uses for recreation, fishing and water supply (Appendix A). The goal is quantitatively expressed in this report as a change or maintenance in lake trophic response to a Carlson's Trophic Status Index score of 60 or less for both chlorophyll-a and secchi disk transparency and maintenance of a dissolved oxygen concentration at 5.0 mg L^{-1} or above. The pollution load targets are set by an amount identified through modeling as probable to result in the quantitatively expressed goal.

6.1 Nutrient Load Reduction Targets

Nutrient load reduction targets are a minimum of 50 percent of the 2001 loads of total nitrogen, nitrate + nitrite as nitrogen and total phosphorus as phosphate, based on the calibrated bathtub trophic response model for Pheasant Lake. The selection of a 50 percent reduction is two-fold: (1) the bathtub model predicted that, under similar hydraulic conditions, an external nutrient load reduction of 50 percent would change Pheasant Lake's trophic status indicators chlorophyll-a and secchi disk to a Carlson's Trophic Status Index Score of 60 or less (Table 34), (Figure 70); and (2) a 50 percent reduction in external load is probably the upper limit of effect a voluntary nonpoint source pollution abatement project could aspire to achieve.

Table 34. Pheasant Lake observed and calibrated trophic response model with a 50 percent reduction in external loads of total phosphorus and total nitrogen

	Value	
Variable	Observed	Model - 50 % Reduction
Total Phosphorus (mg L^{-1})	0.545	0.276
Total Nitrogen (mg L^{-1})	1.468	0.786
Conservative nutrient (Nitrogen, mg L^{-1})	0.108	0.052
Chlorophyll-a (Fg L^{-1})	19.250	17.180
Secchi disk depth (m)	0.960	1.710
Carlson's TSI Phosphorus	95.010	85.200
Carlson's TSI Chlorophyll-a	59.610	58.500
Carlson's TSI Secchi	60.590	52.250

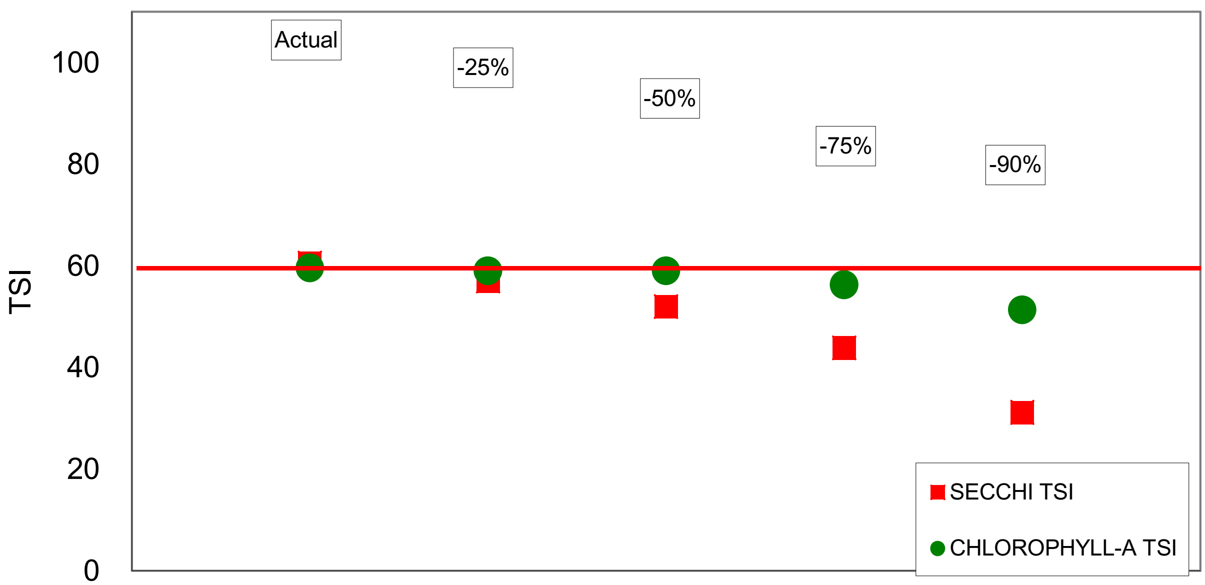


Figure 70. Graphic representation of the calibrated Bathtub trophic response model from incremental reductions in external loads of total nitrogen and total phosphorus of 25, 50, 75 and 90 percent

6.2 Subwatershed Targets

Subwatershed targets for total nitrogen, nitrates, total phosphorus and total suspended solids were developed using the relationship between the AGNPS identified percentage of critical area for soil and nutrient runoff and the measured mass load of soil and the appropriate nutrient (Table 35). The targets were developed by mathematically defining the relationship between the percentage of critical areas for soil erosion and nitrogen and phosphorus delivery to the measured mass load of total suspended solids, total nitrogen, nitrates and total phosphorus. Then, the percentage of critical area in the equation was reduced incrementally until a combined subwatershed reduction in load between 55 and 60 percent was obtained. A flow-weighted concentration was then calculated for each subwatershed, defining discrete goals (Tables 36 through 37), (Figures 75 through 78).

Critical areas are defined in Section 5.5 for soil loss as acres with a predicted soil loss of 5 tons or greater, for nitrogen as nitrogen loss of 3 pounds per acre or greater, and for phosphorus as phosphorus loss of 1.5 pounds per acre or greater during a single 25-year rain event of 4 inches in 24 hours. In total, the percentage of critical area needed to be reduced by 70 percent for soil and phosphorus loss and 65 percent for nitrogen loss in order to achieve an estimated reduction in total suspended solids of 21 percent, total nitrogen of 60 percent, nitrate + nitrite of 55 percent and total phosphorus of 54 percent.

Table 35. Mathematical relationship between AGNPS model and mass loading analysis

Total Suspended Solids Load = 167.79×(M) + 7850.3

Where (M) is the AGNPS model predicted percentage of subwatershed with 5 tons or greater soil loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.5142

Total Nitrogen = 69.796×(M) + 254.88

Where (M) is the AGNPS model predicted percentage of subwatershed with 3 pounds per acre or greater nitrogen loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.8381

Nitrate + Nitrite = 17.339×(M) + 156.02

Where (M) is the AGNPS model predicted percentage of subwatershed with 3 pounds per acre or greater nitrogen loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.7818

Total Phosphorus = 20.895×(M) + 101.12

Where (M) is the AGNPS model predicted percentage of subwatershed with 1.5 pounds per acre or greater phosphorus loss in a single 25-year rain event defined as 4 inches in a 24-hour period.

R-Squared = 0.6239

For total suspended solids, a reduction in the percentage of critical area per subwatershed of 70 percent was selected, even though this only netted a load reduction of 21 percent, for two reasons: (1) total suspended solids were not identified as a significant pollutant contribution to Pheasant Lake; and (2) a 70 percent reduction in critical area of soil erosion would match the reduction target for phosphorus which is intimately linked to both total suspended solids and soil erosion.

The primary strength of this type of target development is that it recognizes the individual physical characteristic of the subwatersheds (i.e., slope, soil type, land use). Its primary weakness is that it assumes all land management practices are equal within the compared subwatersheds at controlling nonpoint source pollution, lumping both the poor and good performers together. A secondary weakness is that the mathematical relationship is not perfect, and on subwatersheds with only a small percentage of critical area there is the possibility that the target load can exceed the 2001 load. This actually occurs on the Northwest subwatershed for total suspended solids and the West subwatershed for total phosphorus (Tables 36 and 39), and Figures (71 and 74).

Table 36. Total suspended solids targets based on a 70 percent reduction in the critical acres per subwatershed.

	Total Suspended Solids (mg L^{-1})	
Tributary	2001 Concentration	Target Concentration
Elm River	5.174	3.9
Northwest	5.394	4.1
West Northwest	4.879	2.6
West	22.642	18.0

	Total Suspended Solids (Kg)	
Tributary	2001 Mass Load	Target Mass Load
Elm River	11,415	8,575
Northwest	8,332	8,883
West Northwest	15,049	9,711
West	10,165	8,300

	Percentage of Critical Area for Soil Loss ($5 tons of soil loss per acre)	
Watershed	2001 Percentage	Target Percentage
Elm River	14.41	4.32
Northwest	20.51	6.15
West Northwest	36.96	11.09
West	8.94	2.68

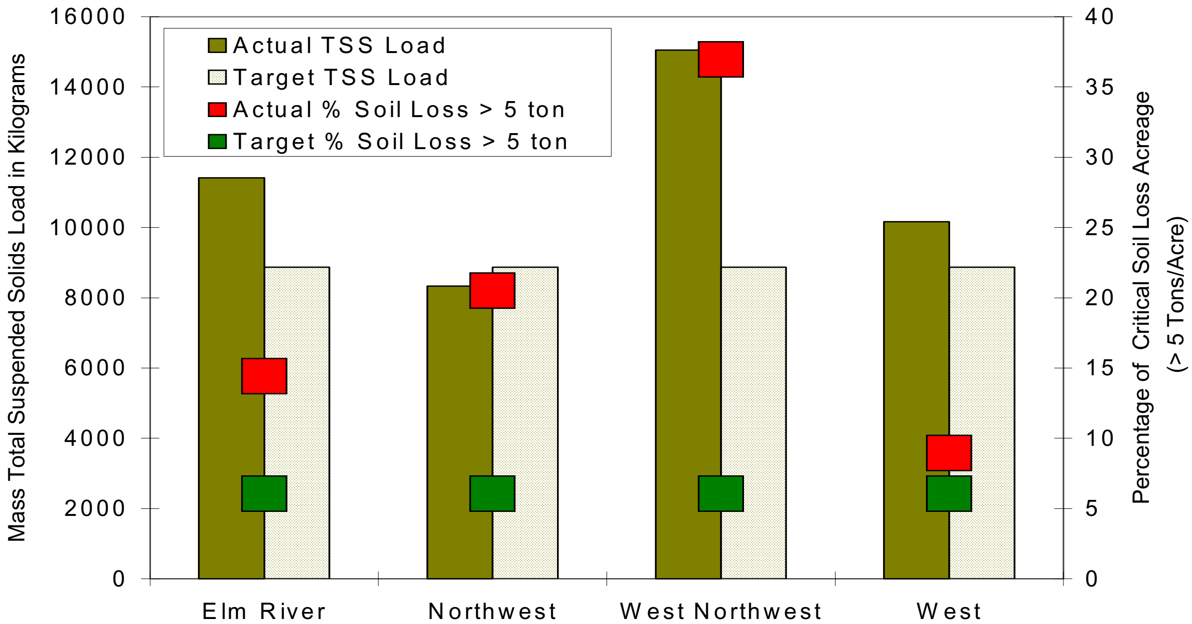


Figure 71. 2001 and target total suspended solids loads and critical reduction targets

Table 37. Total nitrogen 2001 and reduction targets based on a 60 percent reduction in the critical acres per subwatershed

	Total Nitrogen (mg L^{-1})	
Tributary	2001 Concentration	Target Concentration
Elm River	2.069	0.620
Northwest	1.991	1.043
West Northwest	1.787	0.715
West	2.156	1.408

	Total Nitrogen (Kg)	
Tributary	2001 Mass Load	Target Mass Load
Elm River	4,565	1,368
Northwest	3,076	1,465
West Northwest	5,513	2,207
West	968	632

	Percentage of Critical Area for Nitrogen Loss ($3 pounds of nitrogen loss per acre)	
Watershed	2001 Percentage	Target Percentage
Elm River	45.56	15.95
Northwest	49.54	17.34
West Northwest	79.89	27.96
West	15.45	4.15

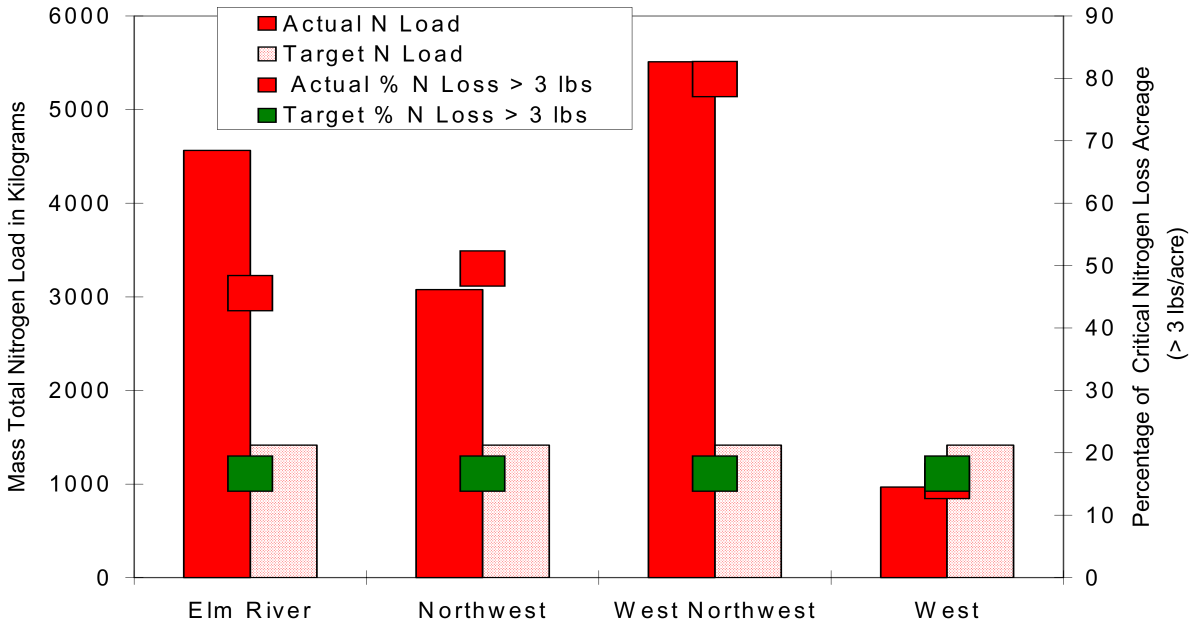


Figure 72. 2001 and target total nitrogen loads and critical area reduction targets

Table 38. Nitrate + nitrate as nitrogen 2001 and reduction targets based on a 60 percent reduction in the critical acres per subwatershed

	Nitrate + Nitrite (mg L^{-1})	
Tributary	2001 Concentration	Target Concentration
Elm River	0.554	0.196
Northwest	0.456	0.296
West Northwest	0.511	0.208
West	0.940	0.557

	Nitrate + Nitrite (Kg)	
Tributary	2001 Mass Load	Target Mass Load
Elm River	1,224	433
Northwest	704	457
West Northwest	1,575	641
West	422	250

	Percentage of Critical Area for Nitrogen Loss ($3 pounds of nitrogen loss per acre)	
Watershed	2001 Percentage	Target Percentage
Elm River	45.56	15.95
Northwest	49.54	17.34
West Northwest	79.89	27.96
West	15.45	5.41

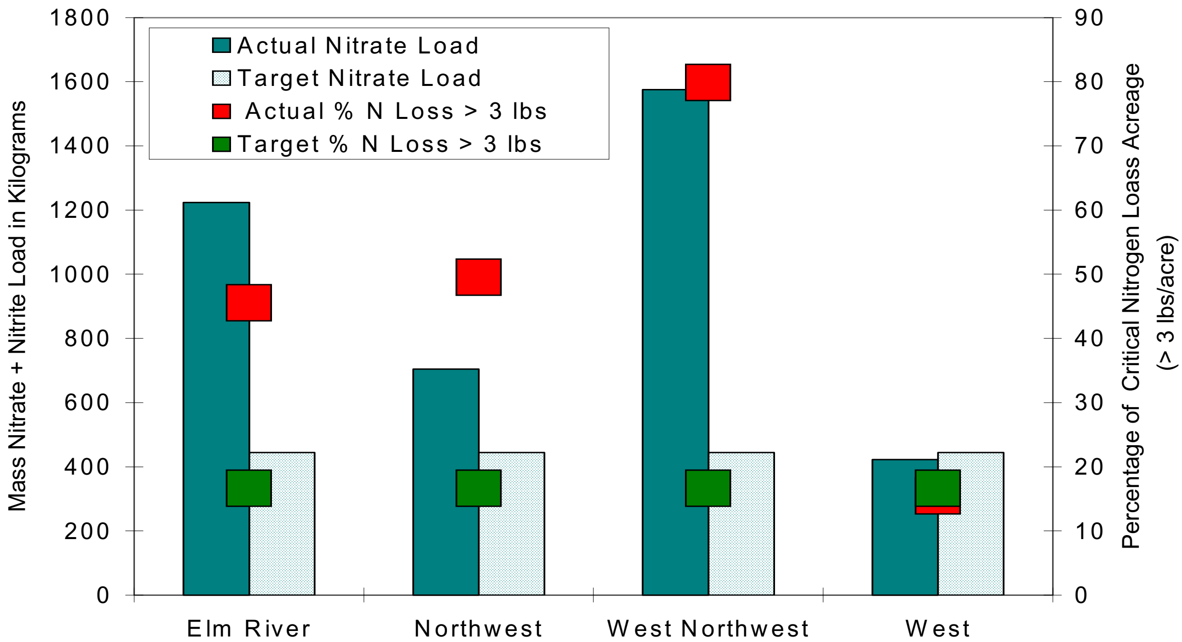


Figure 73. 2001 and target nitrate + nitrite loads and critical area reduction targets

Table 39. Total phosphorus 2001 and reduction targets based on a 70 percent reduction in the critical acres per subwatershed

	Total Phosphorus (mg L^{-1})	
Tributary	2001 Concentration	Target Concentration
Elm River	0.439	0.124
Northwest	0.387	0.212
West Northwest	0.338	0.169
West	0.372	0.419

	Total Phosphorus (Kg)	
Tributary	2001 Mass Load	Target Mass Load
Elm River	1,573	444
Northwest	704	386
West Northwest	1,043	522
West	167	188

	Percentage of Critical Area for Phosphorus Loss ($1.5 pounds of phosphorus loss per acre)	
Watershed	2001 Percentage	Target Percentage
Elm River	54.77	16.43
Northwest	45.39	3.62
West Northwest	67.12	20.14
West	13.82	4.15

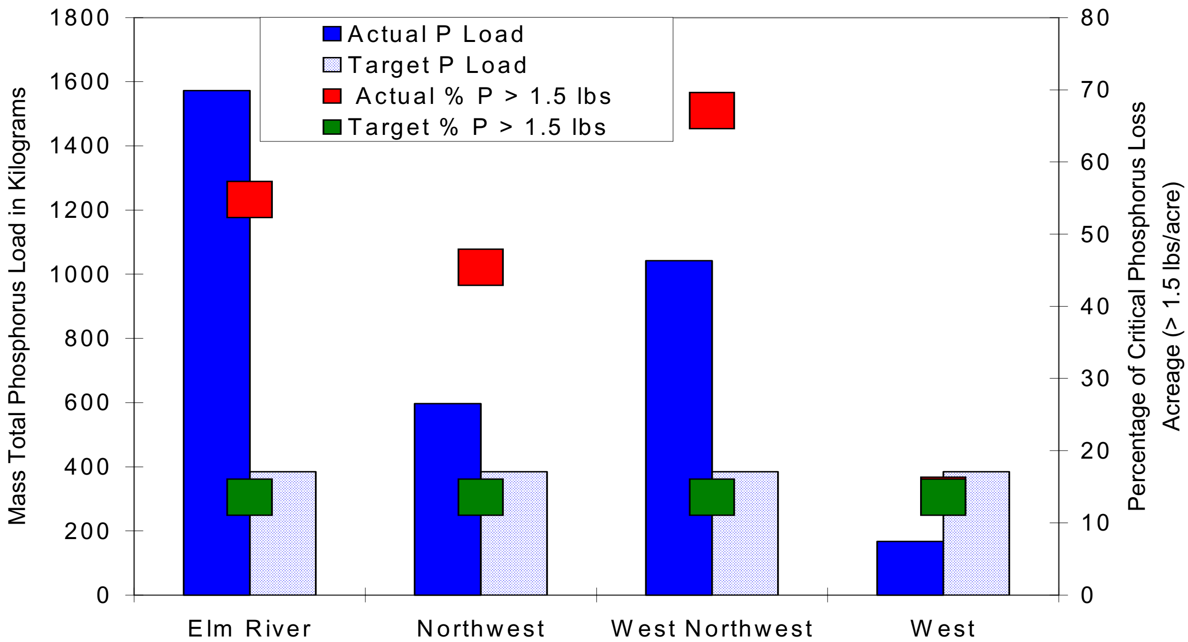


Figure 74. 2001 and target total phosphorus loads and critical area reductions

7.0 MARGIN OF SAFETY

As with most everything, there is a measure of uncertainty in the interpretations and predictions made in this assessment. It is important to recognize that the science of this assessment does not define all the dynamics of Pheasant Lake and the contributing watershed. In order to account for this, both implicit and explicit safety measures were employed in the loading, lake trophic response predictions and the watershed's response to improved land predictions.

The first safety measure was to collect as much data as possible within the short period of time allotted. Additionally, an attempt was also made to sample the likely periods for elevated pollutant loading to minimize the risk of underestimation of load. Secondly, to ensure an accurate loading estimation was made, six different models were explored, and the one least likely to bias the results (as well as having a small coefficient variance and flux variance) was selected.

Explicit measures included (1) selecting a larger in-lake improvement in trophic response than needed to meet the criteria of the goals; (2) selecting watershed load reduction 5 to 10 percent greater than the minimum required; and (3) basing the response on addressing more land mass than is pragmatically possible.

The final measure of safety is recognizing that beyond all modeling results, targets and best professional judgements, the project will not be considered a success until Pheasant Lake has responded in the manner described in the goals of the project. Defining and ensuring this occurrence will entail continued monitoring and refinement of the hydraulic rating curve and lake trophic response modeling.

8.0 RECOMMENDATION

This assessment strongly indicates that, in order to attain the goals as defined by the Quality Assurance Project Plan (Appendix A), the external nutrient load to Pheasant Lake needs to be reduced. The only viable mechanism to achieve a load reduction is through implementation of a watershed nonpoint source pollution reduction project.

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APPENDIX A
PHEASANT LAKE
QUALITY ASSURANCE PROJECT PLAN
(Without Appendixes)

Quality Assurance Project Plan
for the
Pheasant Lake TMDL

Prepared for:
Bruce Zander, Project Officer/TMDL Coordinator
US EPA Region VIII
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Prepared by:
Scott A. Elstad, Environmental Scientist
and
Michael J.Ell, Environmental Administrator
Surface Water Quality Management Program
Division of Water Quality
North Dakota Department of Health
Bismarck, ND

final March 2001

This quality assurance project plan (QAPP) has been prepared according to guidance provided in the EPA document entitled "EPA Requirements for Quality Assurance Project Plans" (EPA 1999 interim final) to ensure that environmental and related data collected, compiled, and/or generated for this program/project are complete, accurate, and of the type, quantity, and quality required for their intended use. The work conducted by the North Dakota Department of Health will be in conformance with the Quality Management Plan for the Department's Environmental Health Section (NDDH, June 2000) and with the procedures described in this QAPP.

Approvals:

Michael J. Ell Program Manager Surface Water Quality Management Program Division of Water Quality North Dakota Department of Health Bismarck, ND	Date	Martin Schock Quality Assurance Coordinator Environmental Health Section North Dakota Department of Health Bismarck, ND	Date

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A. Project Management

A1. Project/Task Organization

This Quality Assurance Project Plan (QAPP) describes the quality assurance (QA) and quality control (QC) activities/procedures that will be used while collecting samples for the Pheasant Lake TMDL Project. The purpose of this document is to present the methods and procedures that will be used to collect chemical and phytoplankton samples from Pheasant Lake and adjacent watershed and the quality assurance procedures that will be employed. This document addresses only the sample collection effort of this project.

Funding for this project has been provided by the US Environmental Protection Agency (EPA) Region 8. The Project Officer for the US EPA is Bruce Zander.

Overall organization for the North Dakota Department Health's Environmental Health Section (EHS) is detailed in the Quality Management Plan (QMP) for the Environmental Health Section (NDDH, June 2000)[1]. The Environmental Health Section is one of four sections in the Department. Within the the EHS there are five divisions, including the Divisions of Air Quality, Municipal Facilities, Waste Management, Water Quality, and Chemistry. Martin Schock is the Quality Assurance Coordinator (QAC) for the EHS. The QAC is located in the EHS Chiefs Office and reports directly to the Chief of the EHS. The EHS Chief's Office through the QAC is responsible for oversight of the EHS's quality system for QA and QC as delineated in the QMP for the EHS, including approving project QAPPs. It is the policy of the EHS that the primary responsibility for QA resides among program staff and Designated Project Managers (DPMs) in each division, therefore each program is responsible for the preparation, implementation, and assessment of its QAPP(s).

Within the EHS, the Division of Water Quality is organized in three programs, the North Dakota Permit Discharge Elimination System (NDPDES) Program, the Groundwater Program, and the Surface Water Quality Management Program (SWQMP). The Pheasant Lake TMDL Project is the responsibility of the SWQMP.

[1] This QAPP was prepared according to the EHS's QMP, which has been approved by EPA.

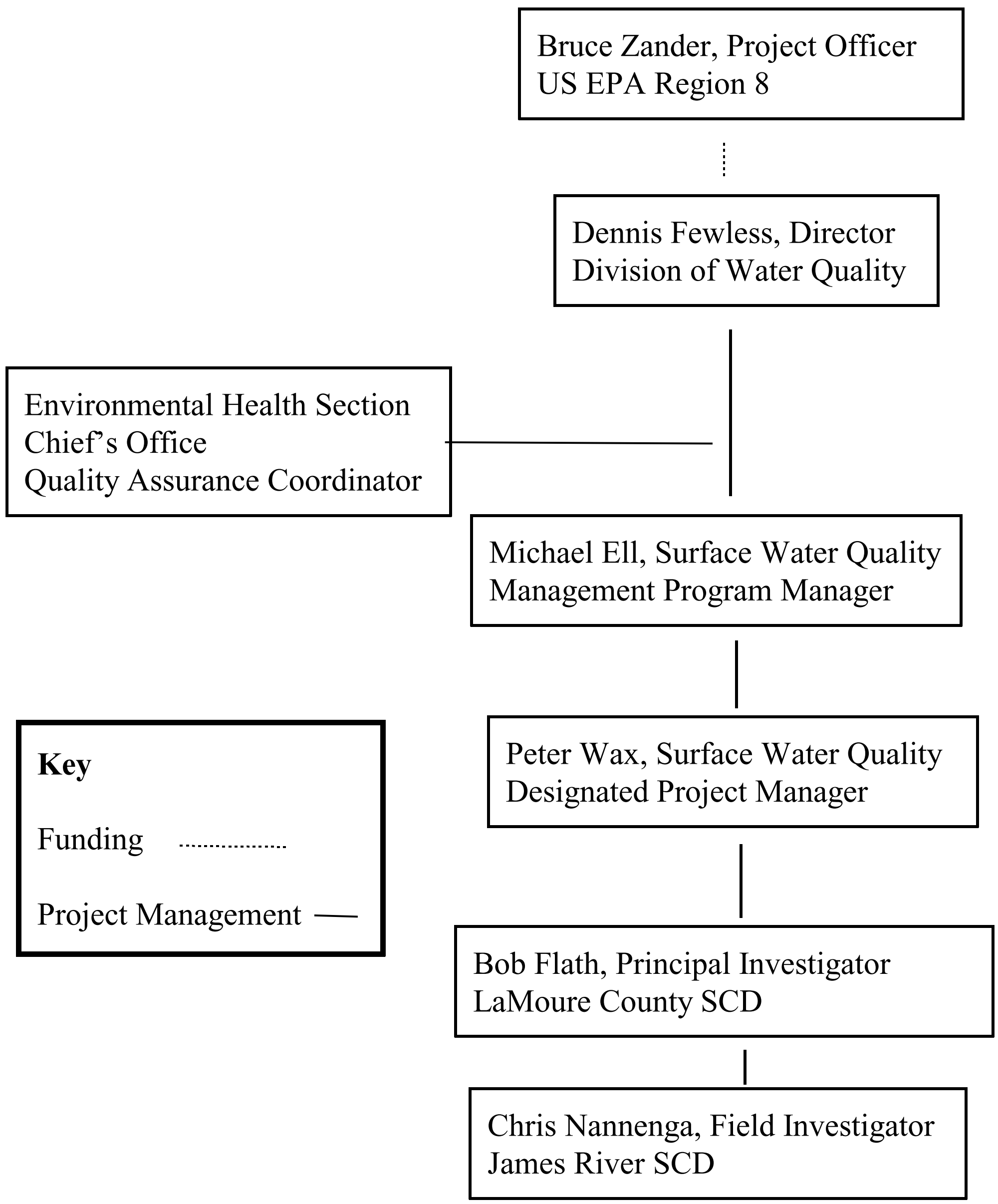

Figure 1. Organizational Diagram for the Pheasant Lake TMDL Project.

Peter Wax is an Environmental Scientist with the SWQMP and is the DPM for the Pheasant Lake TMDL Project. As such, he is responsible for overall project coordination and supervision, including the reduction and analysis of project data and the preparation of the final report. Michael J. Ell, is Program Manager for the SWQMP. As Program Manager in the SWQMP he has the following responsibilities:

- review and edit the QAPP;

- providing oversight for study design, site selection, and adherence to design objectives;

- reviewing and approving the final project workplan and other materials to support the project (e.g., standard operating procedures);

- selecting appropriate project subcontractors, as needed; and

- coordinating with contractors, reviewers, and US EPA to ensure technical quality and contract adherence.

For purposes of this project, project implementation has been contracted to the LaMoure County SCD, Bob Flath is the principle investigator assigned to the project and is responsible for day to day project oversight. Cris Nannenga is the project field investigator and is responsible for data collection and sample custody. The SWQMP will be responsible for data interpretation and report preparation.

A2. Problem Definition Background

Pheasant Lake's watershed varies substantially from east to west. In the west, the topography is composed of rolling hills and intricate drainages, characteristic of the Missouri Coteau physiographic region, a glacial remnant of the late Wisconsin Age. Land use is a mixture of pastures on the steeper slopes and valleys with cultivated lands predominating on the uplands. Throughout the remainder of the watershed topography is much more level and intensely cropped. Soils are mostly deep and well drained from medium textured to moderately fine glacial till. The waterhshed covers approximately 59,520 acres (see Appendix C) and contributes nearly 100 percent of the external pollution loading to Pheasant Lake.

Land use within the Pheasant Lake watershed is 95 percent agricultural with 60 percent in croplands. The remaining 40 percent is in low density urban development, haylands, pastures, conservation reserve program (CRP). According to information provided by the Dickey County Soil Conservation District (SCD), 60 percent of the cultivated lands and 40-80 percent of the remaining lands within the Pheasant Lake watershed are "adequately treated" which still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Pheasant Lake watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 11 to 13 tons per acre which takes into account the untreated portions of the watershed, approximately 791,456 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 79,156 tons to 108,718 tons of soil reaches Pheasant Lake annually.

Other sources of non-point source pollution affecting Pheasant Lake are from the 25 or more cabins and associated waste treatment systems, one golf course and from concentrated livestock feeding areas within the watershed. These sources contribute nutrients to the lake and may be the most significant impact due to their close proximity to the lake. Fertilizer runoff from lawns, agricultural fields, and the construction of new homes are other possible sources of nonpoint source pollution.

A3. Project Goals/Objectives/Tasks Description

The primary goal of this project is to develop a nutrient and sediment total maximum daily load (TMDL) for Pheasant Lake which, if implemented, will improve the lake's trophic status, thereby improving and maintaining its beneficial uses for recreation, fishing and water supply. This will be accomplished by sampling and subsequent analysis of data from five stream and two lake water quality monitoring sites during the summer of 2001 and winter of 2001/2002.

The following objectives and tasks are intended to achieve the goals of the project. Specific milestones and estimated costs for each task are provided with each task. A budget summary for the project is provided in Appendix A.

Objective 1: Conduct a project literature review and prepare a quality assurance project plan (QAPP).

> Task 1: Conduct an extensive literature review of research related to sampling methods and existing data for Pheasant Lake and adjacent watershed in North Dakota.
> Product: Literature review and bibliography.
> Milestone: January 2001
>
> Task 2: Prepare a QAPP and submit it to EHS QAC for approval.
> Product: An approved QAPP.
> Milestone: January 2001
>
> Task 3: Select sampling sites within Pheasant Lake and adjacent watershed.
> Product: A sample set of sites reflecting the hydrology of Pheasant Lake and watershed .
> Milestone: November 2000

Objective 2: Collection and analysis of data and development of the TMDL for Pheasant Lake, Dickey County and surrounding watershed.

> Task 4: Collect and analyze, nine times during the open water season and two times under ice, phytoplankton, chlorophyll-a, and chemical water quality samples from each lake water quality sampling site (Appendices I and J). Chemical water quality samples will be analyzed in the laboratory for pH, specific conductance, major anions and cations, total nitrogen, Total Kjeldahl Nitrogen, nitrate-nitrite, ammonia, and phosphorus (total and dissolved). At the same time as water samples are collected from each site a Secchi disk transparency will be measured (Appendix G) and a temperature/dissolved oxygen profile will measured (Appendix H).
> Product: A temperature and dissolved oxygen profile and phytoplankton, chlorophyll-a, and water quality sample analysis from each lake sampling site.
> Milestone: February 2002

Task 5: Collect and analyze, a minimum of 20, water quality samples from each stream sampling site (Appendix K). Stream water quality samples will be analyzed for total nitrogen, Total Kjeldahl Nitrogen, nitrate-nitrite, ammonia, total phosphorus, total suspended sediment, and fecal coliform bacteria. At the same time as water quality samples are collected temperature and dissolved oxygen will also be measured at each site (Appendix H).
Product: Water quality samples from each stream sampling site.
Milestone: October 2001

Task 6: Collect mean daily stream stage/discharge data from each stream sampling site (Appendices L and M) .
Product: Mean daily stream stage/discharge from each stream sampling site.
Milestone: October 2001

Task 7: Collect event based precipitation data from two locations in the Pheasant Lake watershed.
Product: Event based precipitation data for the Pheasant Lake watershed.
Milestone: October 2001.

Task 8: Characterize watershed landuse (e.g., percent cropland, rangeland, urban, AFO/CAFOs) and condition (e.g., erosion potential) and predict nutrient and sediment loadings from each sub-watershed in the Pheasant Lake watershed using the AGNPS, Version 3.65, watershed model (Appendix N).
Product: A calibrated AGNPS watershed model which can be used to predict sediment and nutient runoff potential with and without sub-watershed landuse changes/BMPs..
Milestone: November 2001

Task 9: Prepare semi-annual, and annual reports describing progress made and a final report summarizing results of the project and a TMDL for Pheasant Lake.
Product: Reports as required.
Milestone: June of 2002.

A4. Data Quality Objectives and Criteria for Measurement Data

A4.1 Data Quality Objectives

It is the policy of the US EPA and the Department's EHS that data quality objectives (DQOs) be developed for all environmental data collection activities. Data of known quality are essential to the success of any monitoring or sampling project. Data quality objectives are qualitative and quantitative statements that clarify the intended use of the data, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data. DQOs are developed by data users to specify the data quality needed to support specific decisions. Sources of error or uncertainty include the following:

- Sampling error: The difference between sample values and *in situ* true values from unknown biases due to collection methods and sampling design;

- Measurement error: The difference between sample values and *in situ* true values associated with the measurement process;

- Natural variation: Natural spacial heterogeneity and temporal variability in population abundance and distribution; and

- Error sources or biases associated with compositing, sampling handling, storage, and preservation.

Methods and procedures described in this document are intended to reduce the magnitude of the sources of uncertainty (and their frequency of occurrence) by applying the following approaches:

- use of standardized sample collection, handling, and analysis procedures; and

- use of trained scientists and technicians to perform the sample collection and handling activities.

A4.2 Measurement Performance Criteria

In order to meet the DQO for the project, the types of data needed for this project and their intended use are described in Table 1. For each of these data, a discussion of the measurement performance criteria or data quality indicators is provided. Data quality indicators include the following:

- precision;
- accuracy;
- representativeness;
- completeness; and
- comparability.

This QAPP does not address measurement performace criteria for the laboratory analysis of chemical samples. Measurement performance criteria for all lab analysis is described in the NDDH, Division of Chemistry, Quality Assurance Plan (NDDH 2000).

Table 1. Project data needs and intended use.

Data Needed	Intended Use
Reservoir physical and biological characteristics: (e.g. nutrients, major ions, temperature, dissolved oxygen, seechi disk transparency, phytoplankton density).	Characterize the general chemical, physical and biological characteristics of Pheasant Lake. Determine the trophic condition, hypolimnetic oxygen depletion rate, and calibrate the BATHTUB trophic response model.
Stream chemical characteristics: (e.g. nutrients, total suspended sediment).	Characterize temporal and spatial variation in stream water quality in the Pheasant Lake watershed and estimate nutrient and sediment loading.
Stream stage/discharge: (E.g. water level, flows)	Develop a stage-discharge rating curve for each site and estimate mean daily discharge based on stream stage.
Watershed/land use characteristics (e.g. AGNPS input variables [see Appendix N) for each 40 acre cell in the Pheasant Lake watershed).	Characterize sources of sediment and nutrient loading within the Pheasant Lake watershed and develop a watershed model that can predict changes in loading due to changes in land use practices.

Precision is a measure of mutual agreement among individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. Precision is best measured in terms of the standard deviation. For purposes of this project, precision of biological samples and chemical analysis will be calculated from replicate samples and expressed as relative percent difference (RPD), if it is calculated from duplicate samples, or as relative standard deviation (RSD), if it is to be calculated from three or more samples. Table 2 provides a summary of the precision requirements for data collected for this project.

Accuracy is the degree of agreement between an observed or measured value and the true or expected value of the measured quality. Many kinds of error, including unintentional bias affect the inherent accuracy of data. Unfortunately, true population values are almost never known to the investigator. This is especially true when working with natural biological communities. Therefore, the best an investigator can do is to avoid bias by assuring consistency of sampling and sample processing and striving for repeatability of measurements. Table 2 provides a summary of the accuracy requirements for data collected for this project.

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter, variations at a sampling point, a process condition or an environmental condition. The representativeness of this project relies, in part, on the selection of sample sites and the collection of a significant number of samples.

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To optimize completeness, every effort is made to avoid sample and/or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data, which will reduce the ability to perform analysis, integrate results, and prepare reports. In order to maximize completeness, all samples will be stored and transported in unbreakable (plastic) containers.

Percent completeness (%C) for measurement parameters and samples is defined as:

$$\%C = v/T \times 100$$

where v = the number of measurements or samples judged valid; and
T = the total number of measurements of samples collected.

In order to fulfill statistical criteria, samples will be collected at 100% of the sites unless unanticipated conditions (i.e. bad weather) prevent sampling. Table 2 provides a summary of the completeness requirements for data collected for this project.

Comparability is a measure of the confidence with which one data set can be compared to another. Comparability is dependent on the proper design of the sampling program and on strict adherence to accepted sampling techniques, standard operating procedures, and quality assurance guidelines. For this project, comparability of data will be accomplished by standardizing the sampling season, the geographic extent of the project, the field sampling methods, and the field training as follows:

- All samples will be collected from specific lake and stream sites located within Pheasant Lake and its watershed watershed (Figures 2 and 3). Further the project sampling period will be between April 2001 and February 2002.

- Standard sampling and analytical methods, as well as standard units of reporting for all parameters sampled will be used (Appendices E-K).

- All field personnel involved with sampling will have adequate training and experience.

Table 2. Summary of precision, accuracy, and completeness requirements for measurement data.

Measurement Parameter	Precision	Accuracy	% Completeness
Lake Sampling			
Water chemistry	20 %	NA	95 %
Field Measurements			
Dissolved Oxygen	$\pm$ 0.1 mg/L	$\pm$ 0.3 mg/L	100 %
Temperature	$\pm$ 0.1 ^{B}C	$\pm$ 0.2 ^{B}C	100 %
Stream Water Quality			
Water Chemistry	20%	NA	95%
Stream Stage/ Discharge	$\pm$5%	0.1 ft/0.1 cfs	99%
AGNPS Model Variables	NA	NA	100%

A5. Special Training/Certification

SCD staff will be responsible for all field water quality, stream stage/discharge, and AGNPS data collection. The field sampling crew are required to have the necessary knowledge and experience to perform all field activities. Training in the proper methods for sample collection, preservation, and the transfer of water chemistry and phytoplankton samples will be provided by Peter Wax, Designated Project Manager. Mr. Wax will also be responsible for assisting SCD staff in the installation of stream staff gauge recording equipment and in providing training in its operation, including providing training in the measurement of stream discharge.

A6. Documents and Records

Thorough documentation of all field sampling and handling activities is necessary for proper processing in the laboratory, data reduction and, ultimately, for the interpretation of study results. Field sample collection and handling will be documented in writing (the following forms and labels will be used):

- a set of Sample Identification/Custody Record forms that accompanies each water chemistry or sediment samples submitted to the Division of Chemistry laboratory for analysis (Appendix D);
- a Sample Identification Label that accompanies and identifies all phytoplankton, chlorophyll-a, and water samples (Appendix E);
- a Lake Temperature/Dissolved Oxygen Profile Recording Form (Appendix F); and
- a Stream Discharge Recording form to calculate instantaneous stream discharge (Appendix L)

Each sample collected will be uniquely identified on the sample label and field custody forms by specifying the site ID and location ; sample depth; and sample date and time.

B. Data Generation and Acquisition

B1. Sampling Process Design

The goal of this project is to develop nutrient and sediment TMDL's for Pheasant Lake which, if implemented, will improve the lake's trophic status, thereby improving and maintaining its beneficial uses for recreation, fishing, and public water supply. This goal will be accomplished by: 1) determining a hydrologic, nutrient and sediment budget for the lake; 2)by identifying the primary causes and sources of nutrients and sediments in the watershed to Pheasant Lake; and 3) examining and making recommendations for lake restoration and/or watershed BMP's which can be implemented to reduce documented sources of nutrient and sediment loading to the lake.

Stream Sampling

For logistical and statistical reasons, the Pheasant Lake watershed will be stratified into five subwatersheds (Appendix C). In each of these five subwatersheds, one stream sampling site will be established and sampled throughout the open water season. Sampling frequency for the stream sampling sites will be stratified to coincide with the typical hydrograph for the region. This sampling design will result in more frequent sampling during spring and early summer, typically when stream discharge is greatest and less frequent sampling during the summer and fall. Sampling will be discontinued during the winter during ice cover. Sampling will also be terminated if the stream stops flowing. If the stream should begin flowing again, water quality sampling will be reinitiated. Table 3 provides a summary of the stream sampling frequency.

Table 3. Sampling frequency for stream monitoring sites.

Sampling Period	Date	Frequency
1st and 2nd month	April - May	twice per week
3rd month	June	once per week
4th - 7th month	July - October	once per month

Lake Sampling

In order to accurately account for temporal variation in lake water quality, each lake sampling site (Appendix B) will be sampled once each month during May, September, October, December 2001 and Feb 2002 and twice each month during June, July and August 2001.

Table 4. Sampling frequency for lake monitoring sites.

Sampling Period	Starting Date	Completion Date
1st Sample Period	May 1st 2001	May 15th 2001
2nd Sample Period	June 1st 2001	June 15th 2001
3rd Sample Period	June 16th 2001	June 30th 2001
4th Sample Period	July 1st 2001	July 15th 2001
5th Sample Period	July 16th 2001	July 31st 2001
6th Sample Period	August 1st 2001	August 15th 2001
7th Sample Period	August 16th 2001	August 31st 2001
8th Sample Period	September 1st 2001	September 15th 2001
9th Sample Period	October 1st 2001	October 15th 2001
10th Sample Period	December 15th 2001	December 31st 2001
11th Sample Period	February 1st 2002	February 15th 2002

Note: This schedule is to be used only as a guide. Actual sampling dates may and probably will differ quite dramatically due to climatic and ice conditions. Under NO conditions will the safety of the sampler be compromised!

During each watershed stream sampling trip, field measurements of temperature and dissolved oxygen will be taken. The measurements will be taken below the waters surface in the center of the stream. During lake sampling trips Secchi disk transparency will be measured (Appendix G) and a water column profile will be taken of temperature and dissolved oxygen. These measurements will start at the surface and continue, at a minimum of one meter increments, to the bottom of the lake (Appendix H).

B2. Sampling Methods

Table 5 provides a summary of project sampling methods. A detailed description of all field sampling methods are described in Appendices G-M.

Table 4. Summary of project sampling methods.

Matrix/ Substrate	Parameter	Sampling Equipment	Max Holding Time	Sample Container	Sample Preservation and Care
Lake Water	Secchi Disk	1	NA	NA	NA
Lake Water	Temp/DO	2	NA	NA	NA
Lake Water	Phytoplankton/ Chlorophyll-a	3	3	3	3
Lake Water	Chemistry	4	4	4	4
Stream Water	Chemistry	5	5	5	5
Stream Discharge		6	NA	NA	NA
Stream Stage		7	NA	NA	NA

1 - See Appendix G.
2 - See Appendix H.
3 - See Appendix I.
4 - See Appendix J.
5 - See Appendix K.
6 - See Appendix L.
7 - See Appendix M.

B3. Sample Handling and Custody Requirements

Following sample collection in the field all water samples will be hand delivered or express mailed to the Division of Chemistry laboratory in Bismarck, North Dakota.

B4. Analytical Methods Requirements

For this project, temperature and dissolved oxygen will be measured in the field using the protocols outlined in the Appendix F. All water samples will be analyzed according methods and procedures described in the NDDH Division of Chemistry's Quality Assurance Plan (NDDH 2000).

B5. Quality Control

For this project, the majority of the measurements (i.e. Secchi disk transparency, temperature, dissolved oxygen) will be taken in the field by a single person. Equipment used for field measurement will be calibrated immediately before and after each sampling trip. Furthermore, field duplicate samples will be collected with ten percent of the stream and lake water samples collected for chemical analysis.

B6. Instrument/Equipment Testing, Inspection and Maintenance

All field equipment will be inspected prior to sampling activities to ensure that proper use requirements are met (e.g., water samplers are without defects, temperature and DO meters properly calibrated). Inspection of field equipment will occur in advance of field activities to allow time for replacement or repair of defective equipment. The Field Investigator should gather and inspect all equipment prior to each sampling trip.

B7. Instrument Calibration and Frequency

As part of instrument and equipment maintenance, temperature and dissolved oxygen meters will be calibrated daily according to the manufacturer's specifications. In addition, the thermometer will be calibrated in the lab prior to the field season against an ASTM standard thermometer and again at the end of the field season to determine drift.

B8. Inspection/Acceptance of Supplies and Consumables

Careful and thorough planning is necessary to ensure the efficient completion of the field sample collection tasks. A general checklist of field equipment and supplies is provided in the description of SOPs (Appendices E-K). It is the responsibility of the Field Investigator to gather and inspect the necessary sampling gear prior to each sampling trip.

B9. Data Acquisition Requirements (Nondirect Measurements)

Non direct measurements will include identification and/or verification of each sample location (i.e., latitude and longitude). The latitude and longitude coordinates, in decimal degrees, will be recorded. A hard copy table of the location of each sampling site and a map depicting each location will be provided by the DPM to the Principle Investigator.

B10. Data Management

Samples will be documented and tracked through sample identification labels, field and laboratory recording forms and sample identification/custody forms. Water samples collected for chemical analysis will be transported or sent to the Division of Chemistry laboratory in Bismarck, ND by field personnel.

Results of chemical analysis of water samples are transmitted from the Division of Chemistry to the SWQMP Program Manager via hard copy report and electronically as an ASCII text file. Results transmitted electronically are stored by the Division of Water Quality's SWQMP in an Access 97 based data management system, termed SID (Sample Identification Database). After review by the SWQMP Program Manager, sample results will be retained by the DPM for data reduction and analysis.

C. Assessment and Oversight

C1. Assessment and Response Actions

Assessment activities and corrective actions have been identified to ensure that sample collection activities are conducted as prescribed and that the measurement quality objectives and data quality objectives established by this QAPP are met. The QA program under which this project will operate includes performance and system audits with independent checks of the data obtained from sampling activities. Either type of audit could indicate the need for corrective action. The essential steps in the program are as follows:

- identify and define the problem;

- assign responsibility for investigating the problem;

- investigate and determine the cause of the problem;

- assign and accept responsibility for implementing appropriate corrective action;

- establish effectiveness of and implement the corrective action; and

- verify that the corrective action has eliminated the problem.

Immediate corrective actions form the part of normal operating procedures and are noted on project field and laboratory recording forms and will be the responsibility of the Field Investigator. Problems not solved this way may require more formalized, long-term corrective action. In the event that quality problems requiring attention are identified, the Principle Investigator and/or the DPM will determine whether attainment of acceptable data quality requires either short- or long-term actions. Failure in the chemical analysis system (e.g., performance requirements are not met) and corrective actions for those failures are beyond the scope of this QAPP.

Communication and oversight will proceed from Field Investigator to the Principle Investigator and DPM. The DPM will be available throughout the entire sampling period to address questions and receive communications of sampling status from the field personnel. Field personnel will communicate the status of the sampling activities to the Principle Investigator and/or DPM on a weekly basis. During this time the field personnel will communicate any sampling difficulties encountered during the sampling and the corrective actions taken. In most cases the field personnel will initiate corrective actions when a problem is immediately identified and note the problem and corrective action in his log book. In the event the problem cannot be corrected immediately, the field personnel will contact the Principle Investigator and/or the DPM to determine the best way to rectify the problem and obtain accurate and useable data. When corrective actions have been taken and a sufficient time period has elapsed that allows a response, the response will be compared with project goals by the DPM. The DPM will verify that the corrective action has been appropriately addressed to eliminate the problem. The DPM has the authority to stop work on the project if problems affecting data quality are identified that will require extensive effort to resolve. When the Principle Investigator and/or DPM are contacted with a problem, the Field Investigator and the Principle Investigator or DPM should keep a record of the problem and the corrective action taken.

Performance audits are qualitative checks on different segments of project activities, and are most appropriate for field sampling and laboratory analysis activities. A field audit of field sampling activities will be conducted at least once during the project. This audit will be conducted early during the project field season in case any problems are identified they can be corrected quickly to minimize the possibility of compromising data. Field audit techniques include checks on sampling equipment and the review of sampling methods.

System audits are qualitative reviews of project activity to check that overall project quality is functioning and that the appropriate QC measures identified in the QAPP are being implemented. The DPM will conduct semi-annual internal system audits during the project and report all deficiencies to the SWQMP Program Manager and the EPA Project Officer during semi-annual reporting.

C2. Reports to Management

Problems and corrective actions identified by the field personnel will be reported to the Principle Investigator and/or DPM each week during the field season. Significant problems identified by the field personnel as well as problems and corrective actions identified by the DPM during the field audit will be reported to the SWQMP Program Manager and the EPA Project Officer as part of annual reports.

D. Data Validation and Usability

D1. Data Review, Validation, and Verification Requirements

Data review and validation services provide a method for determining the usability and limitations of data, and provide a standardized data quality assessment. All field and laboratory report forms will be reviewed by the Principle Investigator and the DPM, while all sample custody forms for chemical analysis will be reviewed by the DPM for completeness and correctness. The Principle Investigator will be responsible for reviewing all data entries and transmittals for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results with the measurement performance criteria summarized in Section A4.2 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the DPM.

D2. Verification and Validation Methods

All field and laboratory record forms will be reviewed by the Principle Investigator. The DPM will review a minimum of five percent of field and laboratory record forms and all of the sample custody forms for chemical analysis. Any discrepancies in the records will be reconciled with the field personnel and recorded in the log book.

Analytical validation and verification methods are outside the scope of the QAPP. The submission of samples to the Division of Chemistry laboratory will include a Sample Identification/Custody Record sheet documenting the site location, sampling date and time. This information will be checked by the the Division of Chemistry laboratory to ensure that holding times have not been exceeded. Violations of holding times will be reported by the laboratory to the DPM. The DPM, in consultation with Division of Chemistry personnel, will determine whether or not to proceed with the analysis of that sample and/or analyte.

D3. Reconciliation with Data Quality Objectives

As soon as possible after each sampling event or the analysis of each sample, calculations and determinations for precision, completeness, and accuracy will be made by the field personnel and compared to the criteria discussed in Section A4. This will represent the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. Any problems in meeting the performance criteria (or uncertainties and limitations in the use of the data) will be discussed with the Principle Investigator and the DPM, and will be reconciled, if possible.

Literature Cited

North Dakota Department of Health. June 2000. Quality Management Plan for the Environmental Health Section. Environmental Health Section, North Dakota Department of Health, Bismarck, ND.

North Dakota Department of Health. 2000. North Dakota State Department of Health Chemistry Division Quality Assurance Plan. North Dakota Department of Health, Division of Chemistry, Bismarck, ND.

EPA. 1999 (interim final). EPA Requirements for Quality Assurance Project Plans. U.S. Environmental Protection Agency, Quality Assurance Division, Washington, D.C. EPA/QA/R-5.

APPENDIX B
WATER QUALITY RESULTS

APPENDIX B1
Water Chemistry Results

DATE_CO	STORET_N	LONG NAME	Result	Units	DEPT
3/26/2001	380017	Ammonia (N)	0.305	mg/L	
3/26/2001	380017	Nitrate + Nitrite (N)	1.36	mg/L	
3/26/2001	380017	Nitrogen (Total	1.58	mg/L	
3/26/2001	380017	Nitrogen (Total)	2.94	mg/L	
3/26/2001	380017	Phosphorus (Total)	0.680	mg/L	
3/26/2001	380017	Suspended Solids	*NON-DETE	mg/L	
3/28/2001	380017	Ammonia (N)	0.282	mg/L	
3/28/2001	380017	Nitrate + Nitrite (N)	1.37	mg/L	
3/28/2001	380017	Nitrogen (Total	1.45	mg/L	
3/28/2001	380017	Nitrogen (Total)	2.82	mg/L	
3/28/2001	380017	Phosphorus (Total)	0.632	mg/L	
3/28/2001	380017	Suspended Solids	*NON-DETE	mg/L	
4/11/2001	380017	Ammonia (N)	0.074	mg/L	
4/11/2001	380017	Nitrate + Nitrite (N)	0.92	mg/L	
4/11/2001	380017	Nitrogen (Total	1.20	mg/L	
4/11/2001	380017	Nitrogen (Total)	2.12	mg/L	
4/11/2001	380017	Phosphorus (Total)	0.390	mg/L	
4/11/2001	380017	Suspended Solids	10.	mg/L	
4/16/2001	380017	Ammonia (N)	0.074	mg/L	
4/16/2001	380017	Nitrate + Nitrite (N)	0.88	mg/L	
4/16/2001	380017	Nitrogen (Total	1.27	mg/L	
4/16/2001	380017	Nitrogen (Total)	2.15	mg/L	
4/16/2001	380017	Phosphorus (Total)	0.408	mg/L	
4/16/2001	380017	Suspended Solids	15.	mg/L	
4/18/2001	380017	Ammonia (N)	0.035	mg/L	
4/18/2001	380017	Nitrate + Nitrite (N)	0.84	mg/L	
4/18/2001	380017	Nitrogen (Total	1.12	mg/L	
4/18/2001	380017	Nitrogen (Total)	1.96	mg/L	
4/18/2001	380017	Phosphorus (Total)	0.408	mg/L	
4/18/2001	380017	Suspended Solids	13.	mg/L	
4/23/2001	380017	Ammonia (N)	0.028	mg/L	
4/23/2001	380017	Nitrate + Nitrite (N)	0.54	mg/L	
4/23/2001	380017	Nitrogen (Total	1.27	mg/L	

4/23/2001	380017	Nitrogen (Total)	1.81	mg/L	
4/23/2001	380017	Phosphorus (Total)	0.408	mg/L	
4/23/2001	380017	Suspended Solids	11.	mg/L	
4/25/2001	380017	Ammonia (N)	0.017	mg/L	
4/25/2001	380017	Nitrate + Nitrite (N)	0.47	mg/L	
4/25/2001	380017	Nitrogen (Total	1.18	mg/L	
4/25/2001	380017	Nitrogen (Total)	1.65	mg/L	
4/25/2001	380017	Phosphorus (Total)	0.391	mg/L	
4/25/2001	380017	Suspended Solids	*NON-DETE	mg/L	
4/3/2001	380017	Ammonia (N)	0.207	mg/L	
4/3/2001	380017	Nitrate + Nitrite (N)	1.18	mg/L	
4/3/2001	380017	Nitrogen (Total	1.44	mg/L	
4/3/2001	380017	Nitrogen (Total)	2.62	mg/L	
4/3/2001	380017	Phosphorus (Total)	0.630	mg/L	
4/3/2001	380017	Suspended Solids	*NON-DETE	mg/L	
4/4/2001	380017	Ammonia (N)	0.227	mg/L	
4/4/2001	380017	Nitrate + Nitrite (N)	1.12	mg/L	
4/4/2001	380017	Nitrogen (Total	1.45	mg/L	
4/4/2001	380017	Nitrogen (Total)	2.57	mg/L	
4/4/2001	380017	Phosphorus (Total)	0.587	mg/L	
4/4/2001	380017	Suspended Solids	*NON-DETE	mg/L	
4/9/2001	380017	Ammonia (N)	0.101	mg/L	
4/9/2001	380017	Nitrate + Nitrite (N)	0.79	mg/L	
4/9/2001	380017	Nitrogen (Total	1.66	mg/L	
4/9/2001	380017	Nitrogen (Total)	2.45	mg/L	
4/9/2001	380017	Phosphorus (Total)	0.436	mg/L	
4/9/2001	380017	Suspended Solids	15.	mg/L	
5/1/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
5/1/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/1/2001	380017	Nitrogen (Total	1.25	mg/L	
5/1/2001	380017	Nitrogen (Total)	1.27	mg/L	
5/1/2001	380017	Phosphorus (Total)	0.318	mg/L	
5/1/2001	380017	Suspended Solids	14.	mg/L	
5/14/2001	380017	Ammonia (N)	*NON-DETE	mg/L	

5/14/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/14/2001	380017	Nitrogen (Total	1.26	mg/L	
5/14/2001	380017	Nitrogen (Total)	1.28	mg/L	
5/14/2001	380017	Phosphorus (Total)	0.334	mg/L	
5/14/2001	380017	Suspended Solids	*NON-DETE	mg/L	
5/16/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
5/16/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/16/2001	380017	Nitrogen (Total	1.24	mg/L	
5/16/2001	380017	Nitrogen (Total)	1.26	mg/L	
5/16/2001	380017	Phosphorus (Total)	0.338	mg/L	
5/16/2001	380017	Suspended Solids	*NON-DETE	mg/L	
5/2/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
5/2/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/2/2001	380017	Nitrogen (Total	1.25	mg/L	
5/2/2001	380017	Nitrogen (Total)	1.27	mg/L	
5/2/2001	380017	Phosphorus (Total)	0.304	mg/L	
5/2/2001	380017	Suspended Solids	11.	mg/L	
5/21/2001	380017	Ammonia (N)	0.111	mg/L	
5/21/2001	380017	Nitrate + Nitrite (N)	0.03	mg/L	
5/21/2001	380017	Nitrogen (Total	1.33	mg/L	
5/21/2001	380017	Nitrogen (Total)	1.36	mg/L	
5/21/2001	380017	Phosphorus (Total)	0.409	mg/L	
5/21/2001	380017	Suspended Solids	6.	mg/L	
5/23/2001	380017	Ammonia (N)	0.130	mg/L	
5/23/2001	380017	Nitrate + Nitrite (N)	0.04	mg/L	
5/23/2001	380017	Nitrogen (Total	1.45	mg/L	
5/23/2001	380017	Nitrogen (Total)	1.49	mg/L	
5/23/2001	380017	Phosphorus (Total)	0.446	mg/L	
5/23/2001	380017	Suspended Solids	10.	mg/L	
5/29/2001	380017	Ammonia (N)	0.141	mg/L	
5/29/2001	380017	Nitrate + Nitrite (N)	0.09	mg/L	
5/29/2001	380017	Nitrogen (Total	1.35	mg/L	
5/29/2001	380017	Nitrogen (Total)	1.44	mg/L	
5/29/2001	380017	Phosphorus (Total)	0.394	mg/L	

5/29/2001	380017	Suspended Solids	10.	mg/L	
5/30/2001	380017	Ammonia (N)	0.112	mg/L	
5/30/2001	380017	Nitrate + Nitrite (N)	0.07	mg/L	
5/30/2001	380017	Nitrogen (Total	1.33	mg/L	
5/30/2001	380017	Nitrogen (Total)	1.40	mg/L	
5/30/2001	380017	Phosphorus (Total)	0.402	mg/L	
5/30/2001	380017	Suspended Solids	13.	mg/L	
5/7/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
5/7/2001	380017	Nitrate + Nitrite (N)	0.02	mg/L	
5/7/2001	380017	Nitrogen (Total	1.16	mg/L	
5/7/2001	380017	Nitrogen (Total)	1.18	mg/L	
5/7/2001	380017	Phosphorus (Total)	0.285	mg/L	
5/7/2001	380017	Suspended Solids	11.	mg/L	
5/9/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
5/9/2001	380017	Nitrate + Nitrite (N)	0.02	mg/L	
5/9/2001	380017	Nitrogen (Total	1.10	mg/L	
5/9/2001	380017	Nitrogen (Total)	1.12	mg/L	
5/9/2001	380017	Phosphorus (Total)	0.272	mg/L	
5/9/2001	380017	Suspended Solids	*NON-DETE	mg/L	
6/11/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
6/11/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/11/2001	380017	Nitrogen (Total	1.29	mg/L	
6/11/2001	380017	Nitrogen (Total)	1.31	mg/L	
6/11/2001	380017	Phosphorus (Total)	0.369	mg/L	
6/11/2001	380017	Suspended Solids	12.	mg/L	
6/13/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
6/13/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/13/2001	380017	Nitrogen (Total	1.27	mg/L	
6/13/2001	380017	Nitrogen (Total)	1.29	mg/L	
6/13/2001	380017	Phosphorus (Total)	0.354	mg/L	
6/13/2001	380017	Suspended Solids	9.	mg/L	
6/18/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
6/18/2001	380017	Nitrate + Nitrite (N)	0.03	mg/L	
6/18/2001	380017	Nitrogen (Total	1.20	mg/L	

6/18/2001	380017	Nitrogen (Total)	1.23	mg/L	
6/18/2001	380017	Phosphorus (Total)	0.384	mg/L	
6/18/2001	380017	Suspended Solids	9.	mg/L	
6/20/2001	380017	Ammonia (N)	0.055	mg/L	
6/20/2001	380017	Nitrate + Nitrite (N)	0.03	mg/L	
6/20/2001	380017	Nitrogen (Total	1.27	mg/L	
6/20/2001	380017	Nitrogen (Total)	1.30	mg/L	
6/20/2001	380017	Phosphorus (Total)	0.443	mg/L	
6/20/2001	380017	Suspended Solids	8.	mg/L	
6/25/2001	380017	Ammonia (N)	*NON-DETE	mg/L	
6/25/2001	380017	Nitrate + Nitrite (N)	0.03	mg/L	
6/25/2001	380017	Nitrogen (Total	1.35	mg/L	
6/25/2001	380017	Nitrogen (Total)	1.38	mg/L	
6/25/2001	380017	Phosphorus (Total)	0.422	mg/L	
6/25/2001	380017	Suspended Solids	8.	mg/L	
6/4/2001	380017	Ammonia (N)	0.010	mg/L	
6/4/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/4/2001	380017	Nitrogen (Total	1.31	mg/L	
6/4/2001	380017	Nitrogen (Total)	1.33	mg/L	
6/4/2001	380017	Phosphorus (Total)	0.409	mg/L	
6/4/2001	380017	Suspended Solids	21.	mg/L	
6/7/2001	380017	Ammonia (N)	0.026	mg/L	
6/7/2001	380017	Nitrate + Nitrite (N)	0.03	mg/L	
6/7/2001	380017	Nitrogen (Total	1.22	mg/L	
6/7/2001	380017	Nitrogen (Total)	1.25	mg/L	
6/7/2001	380017	Phosphorus (Total)	0.378	mg/L	
6/7/2001	380017	Suspended Solids	18.	mg/L	
7/16/2001	380017	Ammonia (N)	0.120	mg/L	
7/16/2001	380017	Nitrate + Nitrite (N)	0.05	mg/L	
7/16/2001	380017	Nitrogen (Total	1.62	mg/L	
7/16/2001	380017	Nitrogen (Total)	1.67	mg/L	
7/16/2001	380017	Phosphorus (Total)	0.535	mg/L	
7/16/2001	380017	Suspended Solids	20.	mg/L	
7/2/2001	380017	Ammonia (N)	0.080	mg/L	

7/2/2001	380017	Nitrate + Nitrite (N)	0.02	mg/L	
7/2/2001	380017	Nitrogen (Total	1.56	mg/L	
7/2/2001	380017	Nitrogen (Total)	1.58	mg/L	
7/2/2001	380017	Phosphorus (Total)	0.611	mg/L	
7/2/2001	380017	Suspended Solids	35.	mg/L	
8/6/2001	380017	Ammonia (N)	0.026	mg/L	
8/6/2001	380017	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/6/2001	380017	Nitrogen (Total	1.41	mg/L	
8/6/2001	380017	Nitrogen (Total)	1.43	mg/L	
8/6/2001	380017	Phosphorus (Total)	0.592	mg/L	
8/6/2001	380017	Suspended Solids	24.	mg/L	
9/7/2001	380017	Ammonia (N)	0.069	mg/L	
9/7/2001	380017	Nitrate + Nitrite (N)	0.04	mg/L	
9/7/2001	380017	Nitrogen (Total	2.43	mg/L	
9/7/2001	380017	Nitrogen (Total)	2.47	mg/L	
9/7/2001	380017	Phosphorus (Total)	0.655	mg/L	
1/9/2002	381125	Ammonia (N)	0.030	mg/L	
1/9/2002	381125	Dissolved	0.355	mg/L	
1/9/2002	381125	Nitrate + Nitrite (N)	0.08	mg/L	
1/9/2002	381125	Nitrogen (Total	1.62	mg/L	
1/9/2002	381125	Nitrogen (Total)	1.70	mg/L	
1/9/2002	381125	Phosphorus (Total)	0.402	mg/L	
1/9/2002	381125	Ammonia (N)	0.030	mg/L	
1/9/2002	381125	Dissolved	0.366	mg/L	
1/9/2002	381125	Nitrate + Nitrite (N)	0.07	mg/L	
1/9/2002	381125	Nitrogen (Total	1.53	mg/L	
1/9/2002	381125	Nitrogen (Total)	1.60	mg/L	
1/9/2002	381125	Phosphorus (Total)	0.398	mg/L	
1/9/2002	381125	Ammonia (N)	0.035	mg/L	
1/9/2002	381125	Dissolved	0.371	mg/L	
1/9/2002	381125	Nitrate + Nitrite (N)	0.09	mg/L	
1/9/2002	381125	Nitrogen (Total	1.56	mg/L	
1/9/2002	381125	Nitrogen (Total)	1.65	mg/L	
1/9/2002	381125	Phosphorus (Total)	0.408	mg/L	

10/29/2001	381125	Ammonia (N)	0.027	mg/L	
10/29/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
10/29/2001	381125	Nitrogen (Total	1.44	mg/L	
10/29/2001	381125	Nitrogen (Total)	1.46	mg/L	
10/29/2001	381125	Phosphorus (Total)	0.416	mg/L	
10/29/2001	381125	Ammonia (N)	0.033	mg/L	
10/29/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
10/29/2001	381125	Nitrogen (Total	1.46	mg/L	
10/29/2001	381125	Nitrogen (Total)	1.48	mg/L	
10/29/2001	381125	Phosphorus (Total)	0.414	mg/L	
10/29/2001	381125	Ammonia (N)	0.027	mg/L	
10/29/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
10/29/2001	381125	Nitrogen (Total	1.42	mg/L	
10/29/2001	381125	Nitrogen (Total)	1.44	mg/L	
10/29/2001	381125	Phosphorus (Total)	0.416	mg/L	
10/29/2001	381125	Chlorophyll A	*NON-DETE	mg/L	
10/29/2001	381125	Chlorophyll B	*NON-DETE	mg/L	
2/7/2002	381125	Ammonia (N)	*NON-DETE	mg/L	
2/7/2002	381125	Dissolved	0.370	mg/L	
2/7/2002	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
2/7/2002	381125	Nitrogen (Total	1.69	mg/L	
2/7/2002	381125	Nitrogen (Total)	1.71	mg/L	
2/7/2002	381125	Phosphorus (Total)	0.426	mg/L	
2/7/2002	381125	Ammonia (N)	*NON-DETE	mg/L	
2/7/2002	381125	Dissolved	0.392	mg/L	
2/7/2002	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
2/7/2002	381125	Nitrogen (Total	1.54	mg/L	
2/7/2002	381125	Nitrogen (Total)	1.56	mg/L	
2/7/2002	381125	Phosphorus (Total)	0.474	mg/L	
2/7/2002	381125	Ammonia (N)	*NON-DETE	mg/L	
2/7/2002	381125	Dissolved	0.368	mg/L	
2/7/2002	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
2/7/2002	381125	Nitrogen (Total	1.62	mg/L	
2/7/2002	381125	Nitrogen (Total)	1.64	mg/L	

2/7/2002	381125	Phosphorus (Total)	0.430	mg/L	
6/22/2001	381125	Ammonia (N)	0.014	mg/L	
6/22/2001	381125	Dissolved	0.391	mg/L	
6/22/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/22/2001	381125	Nitrogen (Total	1.24	mg/L	
6/22/2001	381125	Nitrogen (Total)	1.26	mg/L	
6/22/2001	381125	Phosphorus (Total)	0.446	mg/L	
6/22/2001	381125	Ammonia (N)	0.012	mg/L	
6/22/2001	381125	Dissolved	0.389	mg/L	
6/22/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/22/2001	381125	Nitrogen (Total	1.24	mg/L	
6/22/2001	381125	Nitrogen (Total)	1.26	mg/L	
6/22/2001	381125	Phosphorus (Total)	0.449	mg/L	
6/22/2001	381125	Ammonia (N)	0.024	mg/L	
6/22/2001	381125	Dissolved	0.416	mg/L	
6/22/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/22/2001	381125	Nitrogen (Total	1.25	mg/L	
6/22/2001	381125	Nitrogen (Total)	1.27	mg/L	
6/22/2001	381125	Phosphorus (Total)	0.469	mg/L	
6/22/2001	381125	Chlorophyll A	*NON-DETE	mg/L	
6/22/2001	381125	Chlorophyll B	*NON-DETE	mg/L	
6/4/2001	381125	Ammonia (N)	*NON-DETE	mg/L	
6/4/2001	381125	Dissolved	0.386	mg/L	
6/4/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/4/2001	381125	Nitrogen (Total	1.26	mg/L	
6/4/2001	381125	Nitrogen (Total)	1.28	mg/L	
6/4/2001	381125	Phosphorus (Total)	0.413	mg/L	
6/4/2001	381125	Ammonia (N)	*NON-DETE	mg/L	
6/4/2001	381125	Dissolved	0.379	mg/L	
6/4/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/4/2001	381125	Nitrogen (Total	1.27	mg/L	
6/4/2001	381125	Nitrogen (Total)	1.29	mg/L	
6/4/2001	381125	Phosphorus (Total)	0.419	mg/L	
7/25/2001	381125	Ammonia (N)	0.062	mg/L	

7/25/2001	381125	Dissolved	0.550	mg/L	
7/25/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
7/25/2001	381125	Nitrogen (Total	1.60	mg/L	
7/25/2001	381125	Nitrogen (Total)	1.62	mg/L	
7/25/2001	381125	Phosphorus (Total)	0.602	mg/L	
7/25/2001	381125	Ammonia (N)	0.062	mg/L	
7/25/2001	381125	Dissolved	0.523	mg/L	
7/25/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
7/25/2001	381125	Nitrogen (Total	1.57	mg/L	
7/25/2001	381125	Nitrogen (Total)	1.59	mg/L	
7/25/2001	381125	Phosphorus (Total)	0.600	mg/L	
7/25/2001	381125	Ammonia (N)	0.051	mg/L	
7/25/2001	381125	Dissolved	0.528	mg/L	
7/25/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
7/25/2001	381125	Nitrogen (Total	1.51	mg/L	
7/25/2001	381125	Nitrogen (Total)	1.53	mg/L	
7/25/2001	381125	Phosphorus (Total)	0.602	mg/L	
7/25/2001	381125	Chlorophyll A	12.0	mg/L	
7/25/2001	381125	Chlorophyll B	*NON-DETE	mg/L	
8/16/2001	381125	Chlorophyll A	30.0	mg/L	
8/16/2001	381125	Chlorophyll B	3.00	mg/L	
8/16/2001	381125	Ammonia (N)	0.013	mg/L	
8/16/2001	381125	Dissolved	0.493	mg/L	
8/16/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/16/2001	381125	Nitrogen (Total	1.54	mg/L	
8/16/2001	381125	Nitrogen (Total)	1.56	mg/L	
8/16/2001	381125	Phosphorus (Total)	0.613	mg/L	
8/16/2001	381125	Ammonia (N)	0.015	mg/L	
8/16/2001	381125	Dissolved	0.504	mg/L	
8/16/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/16/2001	381125	Nitrogen (Total	1.60	mg/L	
8/16/2001	381125	Nitrogen (Total)	1.62	mg/L	
8/16/2001	381125	Phosphorus (Total)	0.623	mg/L	
8/16/2001	381125	Ammonia (N)	0.014	mg/L	

8/16/2001	381125	Dissolved	0.481	mg/L	
8/16/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/16/2001	381125	Nitrogen (Total	1.54	mg/L	
8/16/2001	381125	Nitrogen (Total)	1.56	mg/L	
8/16/2001	381125	Phosphorus (Total)	0.602	mg/L	
8/2/2001	381125	Ammonia (N)	0.021	mg/L	
8/2/2001	381125	Dissolved	0.549	mg/L	
8/2/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/2/2001	381125	Nitrogen (Total	1.57	mg/L	
8/2/2001	381125	Nitrogen (Total)	1.59	mg/L	
8/2/2001	381125	Phosphorus (Total)	0.667	mg/L	
8/2/2001	381125	Ammonia (N)	0.025	mg/L	
8/2/2001	381125	Dissolved	0.619	mg/L	
8/2/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/2/2001	381125	Nitrogen (Total	1.84	mg/L	
8/2/2001	381125	Nitrogen (Total)	1.86	mg/L	
8/2/2001	381125	Phosphorus (Total)	0.727	mg/L	
8/2/2001	381125	Ammonia (N)	0.015	mg/L	
8/2/2001	381125	Dissolved	0.541	mg/L	
8/2/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/2/2001	381125	Nitrogen (Total	1.46	mg/L	
8/2/2001	381125	Nitrogen (Total)	1.48	mg/L	
8/2/2001	381125	Phosphorus (Total)	0.638	mg/L	
8/2/2001	381125	Chlorophyll A	13.0	mg/L	
8/2/2001	381125	Chlorophyll B	*NON-DETE	mg/L	
8/29/2001	381125	Ammonia (N)	*NON-DETE	mg/L	
8/29/2001	381125	Dissolved	0.558	mg/L	
8/29/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/29/2001	381125	Nitrogen (Total	1.52	mg/L	
8/29/2001	381125	Nitrogen (Total)	1.54	mg/L	
8/29/2001	381125	Phosphorus (Total)	0.650	mg/L	
8/29/2001	381125	Ammonia (N)	*NON-DETE	mg/L	
8/29/2001	381125	Dissolved	0.531	mg/L	
8/29/2001	381125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	

8/29/2001	381125	Nitrogen (Total	1.60	mg/L	
8/29/2001	381125	Nitrogen (Total)	1.62	mg/L	
8/29/2001	381125	Phosphorus (Total)	0.653	mg/L	
8/29/2001	381125	Chlorophyll A	15.0	mg/L	
8/29/2001	381125	Chlorophyll B	2.00	mg/L	
9/20/2001	381125	Ammonia (N)	0.077	mg/L	
9/20/2001	381125	Nitrate + Nitrite (N)	0.02	mg/L	
9/20/2001	381125	Nitrogen (Total	1.44	mg/L	
9/20/2001	381125	Nitrogen (Total)	1.46	mg/L	
9/20/2001	381125	Phosphorus (Total)	0.511	mg/L	
9/20/2001	381125	Ammonia (N)	0.070	mg/L	
9/20/2001	381125	Nitrate + Nitrite (N)	0.02	mg/L	
9/20/2001	381125	Nitrogen (Total	1.42	mg/L	
9/20/2001	381125	Nitrogen (Total)	1.44	mg/L	
9/20/2001	381125	Phosphorus (Total)	0.521	mg/L	
9/20/2001	381125	Ammonia (N)	0.073	mg/L	
9/20/2001	381125	Nitrate + Nitrite (N)	0.02	mg/L	
9/20/2001	381125	Nitrogen (Total	1.37	mg/L	
9/20/2001	381125	Nitrogen (Total)	1.39	mg/L	
9/20/2001	381125	Phosphorus (Total)	0.516	mg/L	
9/20/2001	381125	Chlorophyll A	*NON-DETE	mg/L	
9/20/2001	381125	Chlorophyll B	*NON-DETE	mg/L	
1/9/2002	381127	Ammonia (N)	*NON-DETE	mg/L	
1/9/2002	381127	Dissolved	0.357	mg/L	
1/9/2002	381127	Nitrate + Nitrite (N)	0.06	mg/L	
1/9/2002	381127	Nitrogen (Total	1.56	mg/L	
1/9/2002	381127	Nitrogen (Total)	1.62	mg/L	
1/9/2002	381127	Phosphorus (Total)	0.396	mg/L	
10/29/2001	381127	Ammonia (N)	0.044	mg/L	
10/29/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
10/29/2001	381127	Nitrogen (Total	1.49	mg/L	
10/29/2001	381127	Nitrogen (Total)	1.51	mg/L	
10/29/2001	381127	Phosphorus (Total)	0.410	mg/L	
2/7/2002	381127	Ammonia (N)	0.028	mg/L	

2/7/2002	381127	Dissolved	0.368	mg/L	
2/7/2002	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
2/7/2002	381127	Nitrogen (Total	1.75	mg/L	
2/7/2002	381127	Nitrogen (Total)	1.77	mg/L	
2/7/2002	381127	Phosphorus (Total)	0.418	mg/L	
6/22/2001	381127	Ammonia (N)	*NON-DETE	mg/L	
6/22/2001	381127	Dissolved	0.404	mg/L	
6/22/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/22/2001	381127	Nitrogen (Total	1.25	mg/L	
6/22/2001	381127	Nitrogen (Total)	1.27	mg/L	
6/22/2001	381127	Phosphorus (Total)	0.436	mg/L	
6/4/2001	381127	Ammonia (N)	0.042	mg/L	
6/4/2001	381127	Dissolved	0.394	mg/L	
6/4/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/4/2001	381127	Nitrogen (Total	1.37	mg/L	
6/4/2001	381127	Nitrogen (Total)	1.39	mg/L	
6/4/2001	381127	Phosphorus (Total)	0.450	mg/L	
7/25/2001	381127	Ammonia (N)	0.020	mg/L	
7/25/2001	381127	Dissolved	0.521	mg/L	
7/25/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
7/25/2001	381127	Nitrogen (Total	1.55	mg/L	
7/25/2001	381127	Nitrogen (Total)	1.57	mg/L	
7/25/2001	381127	Phosphorus (Total)	0.603	mg/L	
8/16/2001	381127	Ammonia (N)	0.013	mg/L	
8/16/2001	381127	Dissolved	0.468	mg/L	
8/16/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/16/2001	381127	Nitrogen (Total	1.59	mg/L	
8/16/2001	381127	Nitrogen (Total)	1.61	mg/L	
8/16/2001	381127	Phosphorus (Total)	0.590	mg/L	
8/2/2001	381127	Ammonia (N)	0.035	mg/L	
8/2/2001	381127	Dissolved	0.502	mg/L	
8/2/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/2/2001	381127	Nitrogen (Total	1.51	mg/L	
8/2/2001	381127	Nitrogen (Total)	1.53	mg/L	

8/2/2001	381127	Phosphorus (Total)	0.609	mg/L	
8/29/2001	381127	Ammonia (N)	*NON-DETE	mg/L	
8/29/2001	381127	Dissolved	0.523	mg/L	
8/29/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/29/2001	381127	Nitrogen (Total	1.52	mg/L	
8/29/2001	381127	Nitrogen (Total)	1.54	mg/L	
8/29/2001	381127	Phosphorus (Total)	0.629	mg/L	
9/20/2001	381127	Ammonia (N)	*NON-DETE	mg/L	
9/20/2001	381127	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
9/20/2001	381127	Nitrogen (Total	1.42	mg/L	
9/20/2001	381127	Nitrogen (Total)	1.44	mg/L	
9/20/2001	381127	Phosphorus (Total)	0.516	mg/L	
8/29/2001	381135	Ammonia (N)	*NON-DETE	mg/L	
8/29/2001	381135	Dissolved	0.546	mg/L	
8/29/2001	381135	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/29/2001	381135	Nitrogen (Total	1.59	mg/L	
8/29/2001	381135	Nitrogen (Total)	1.61	mg/L	
8/29/2001	381135	Phosphorus (Total)	0.627	mg/L	
6/4/2001	384125	Ammonia (N)	0.031	mg/L	
6/4/2001	384125	Dissolved	0.389	mg/L	
6/4/2001	384125	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/4/2001	384125	Nitrogen (Total	1.34	mg/L	
6/4/2001	384125	Nitrogen (Total)	1.36	mg/L	
6/4/2001	384125	Phosphorus (Total)	0.449	mg/L	
10/10/2001	385080	Ammonia (N)	0.024	mg/L	
10/10/2001	385080	Nitrate + Nitrite (N)	0.14	mg/L	
10/10/2001	385080	Nitrogen (Total	1.65	mg/L	
10/10/2001	385080	Nitrogen (Total)	1.79	mg/L	
10/10/2001	385080	Phosphorus (Total)	0.375	mg/L	
10/10/2001	385080	Suspended Solids	9.	mg/L	
3/21/2001	385080	Ammonia (N)	0.151	mg/L	
3/21/2001	385080	Nitrate + Nitrite (N)	1.49	mg/L	
3/21/2001	385080	Nitrogen (Total	1.50	mg/L	
3/21/2001	385080	Nitrogen (Total)	2.99	mg/L	

3/21/2001	385080	Phosphorus (Total)	0.710	mg/L	
3/21/2001	385080	Suspended Solids	10.	mg/L	
3/26/2001	385080	Ammonia (N)	0.112	mg/L	
3/26/2001	385080	Nitrate + Nitrite (N)	1.81	mg/L	
3/26/2001	385080	Nitrogen (Total	1.50	mg/L	
3/26/2001	385080	Nitrogen (Total)	3.31	mg/L	
3/26/2001	385080	Phosphorus (Total)	0.716	mg/L	
3/26/2001	385080	Suspended Solids	52.	mg/L	
3/28/2001	385080	Ammonia (N)	0.227	mg/L	
3/28/2001	385080	Nitrate + Nitrite (N)	1.16	mg/L	
3/28/2001	385080	Nitrogen (Total	1.36	mg/L	
3/28/2001	385080	Nitrogen (Total)	2.52	mg/L	
3/28/2001	385080	Phosphorus (Total)	0.536	mg/L	
3/28/2001	385080	Suspended Solids	*NON-DETE	mg/L	
4/11/2001	385080	Ammonia (N)	0.015	mg/L	
4/11/2001	385080	Nitrate + Nitrite (N)	1.28	mg/L	
4/11/2001	385080	Nitrogen (Total	0.940	mg/L	
4/11/2001	385080	Nitrogen (Total)	2.22	mg/L	
4/11/2001	385080	Phosphorus (Total)	0.307	mg/L	
4/11/2001	385080	Suspended Solids	*NON-DETE	mg/L	
4/16/2001	385080	Ammonia (N)	0.012	mg/L	
4/16/2001	385080	Nitrate + Nitrite (N)	0.06	mg/L	
4/16/2001	385080	Nitrogen (Total	0.940	mg/L	
4/16/2001	385080	Nitrogen (Total)	1.00	mg/L	
4/16/2001	385080	Phosphorus (Total)	0.224	mg/L	
4/16/2001	385080	Suspended Solids	*NON-DETE	mg/L	
4/18/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
4/18/2001	385080	Nitrate + Nitrite (N)	0.07	mg/L	
4/18/2001	385080	Nitrogen (Total	0.855	mg/L	
4/18/2001	385080	Nitrogen (Total)	0.925	mg/L	
4/18/2001	385080	Phosphorus (Total)	0.204	mg/L	
4/18/2001	385080	Suspended Solids	23.	mg/L	
4/23/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
4/23/2001	385080	Nitrate + Nitrite (N)	0.21	mg/L	

4/23/2001	385080	Nitrogen (Total	0.840	mg/L	
4/23/2001	385080	Nitrogen (Total)	1.05	mg/L	
4/23/2001	385080	Phosphorus (Total)	0.150	mg/L	
4/23/2001	385080	Suspended Solids	8.	mg/L	
4/25/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
4/25/2001	385080	Nitrate + Nitrite (N)	0.09	mg/L	
4/25/2001	385080	Nitrogen (Total	0.970	mg/L	
4/25/2001	385080	Nitrogen (Total)	1.06	mg/L	
4/25/2001	385080	Phosphorus (Total)	0.161	mg/L	
4/25/2001	385080	Suspended Solids	32.	mg/L	
4/29/2002	385080	Ammonia (N)	0.048	mg/L	
4/29/2002	385080	Nitrate + Nitrite (N)	0.21	mg/L	
4/29/2002	385080	Nitrogen (Total	1.41	mg/L	
4/29/2002	385080	Nitrogen (Total)	1.62	mg/L	
4/29/2002	385080	Phosphorus (Total)	0.108	mg/L	
4/29/2002	385080	Suspended Solids	*NON-DETE	mg/L	
4/3/2001	385080	Ammonia (N)	0.044	mg/L	
4/3/2001	385080	Nitrate + Nitrite (N)	0.31	mg/L	
4/3/2001	385080	Nitrogen (Total	1.05	mg/L	
4/3/2001	385080	Nitrogen (Total)	1.36	mg/L	
4/3/2001	385080	Phosphorus (Total)	0.344	mg/L	
4/3/2001	385080	Suspended Solids	*NON-DETE	mg/L	
4/4/2001	385080	Ammonia (N)	0.062	mg/L	
4/4/2001	385080	Nitrate + Nitrite (N)	0.38	mg/L	
4/4/2001	385080	Nitrogen (Total	0.990	mg/L	
4/4/2001	385080	Nitrogen (Total)	1.37	mg/L	
4/4/2001	385080	Phosphorus (Total)	0.305	mg/L	
4/4/2001	385080	Suspended Solids	*NON-DETE	mg/L	
4/9/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
4/9/2001	385080	Nitrate + Nitrite (N)	2.47	mg/L	
4/9/2001	385080	Nitrogen (Total	1.20	mg/L	
4/9/2001	385080	Nitrogen (Total)	3.67	mg/L	
4/9/2001	385080	Phosphorus (Total)	0.368	mg/L	
4/9/2001	385080	Suspended Solids	7.	mg/L	

5/1/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
5/1/2001	385080	Nitrate + Nitrite (N)	0.02	mg/L	
5/1/2001	385080	Nitrogen (Total	1.08	mg/L	
5/1/2001	385080	Nitrogen (Total)	1.10	mg/L	
5/1/2001	385080	Phosphorus (Total)	0.211	mg/L	
5/1/2001	385080	Suspended Solids	18.	mg/L	
5/14/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
5/14/2001	385080	Nitrate + Nitrite (N)	0.02	mg/L	
5/14/2001	385080	Nitrogen (Total	1.34	mg/L	
5/14/2001	385080	Nitrogen (Total)	1.36	mg/L	
5/14/2001	385080	Phosphorus (Total)	0.245	mg/L	
5/14/2001	385080	Suspended Solids	*NON-DETE	mg/L	
5/2/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
5/2/2001	385080	Nitrate + Nitrite (N)	0.02	mg/L	
5/2/2001	385080	Nitrogen (Total	1.07	mg/L	
5/2/2001	385080	Nitrogen (Total)	1.09	mg/L	
5/2/2001	385080	Phosphorus (Total)	0.205	mg/L	
5/2/2001	385080	Suspended Solids	*NON-DETE	mg/L	
5/7/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
5/7/2001	385080	Nitrate + Nitrite (N)	0.07	mg/L	
5/7/2001	385080	Nitrogen (Total	1.54	mg/L	
5/7/2001	385080	Nitrogen (Total)	1.61	mg/L	
5/7/2001	385080	Phosphorus (Total)	0.288	mg/L	
5/7/2001	385080	Suspended Solids	106.	mg/L	
5/9/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
5/9/2001	385080	Nitrate + Nitrite (N)	0.02	mg/L	
5/9/2001	385080	Nitrogen (Total	1.36	mg/L	
5/9/2001	385080	Nitrogen (Total)	1.38	mg/L	
5/9/2001	385080	Phosphorus (Total)	0.209	mg/L	
5/9/2001	385080	Suspended Solids	*NON-DETE	mg/L	
6/7/2001	385080	Ammonia (N)	*NON-DETE	mg/L	
6/7/2001	385080	Nitrate + Nitrite (N)	0.02	mg/L	
6/7/2001	385080	Nitrogen (Total	1.19	mg/L	
6/7/2001	385080	Nitrogen (Total)	1.21	mg/L	

6/7/2001	385080	Phosphorus (Total)	0.196	mg/L	
6/7/2001	385080	Suspended Solids	*NON-DETE	mg/L	
3/21/2001	385081	Ammonia (N)	0.416	mg/L	
3/21/2001	385081	Nitrate + Nitrite (N)	1.80	mg/L	
3/21/2001	385081	Nitrogen (Total	2.01	mg/L	
3/21/2001	385081	Nitrogen (Total)	3.81	mg/L	
3/21/2001	385081	Phosphorus (Total)	0.818	mg/L	
3/21/2001	385081	Suspended Solids	8.	mg/L	
3/26/2001	385081	Ammonia (N)	0.256	mg/L	
3/26/2001	385081	Nitrate + Nitrite (N)	1.96	mg/L	
3/26/2001	385081	Nitrogen (Total	1.60	mg/L	
3/26/2001	385081	Nitrogen (Total)	3.56	mg/L	
3/26/2001	385081	Phosphorus (Total)	0.812	mg/L	
3/26/2001	385081	Suspended Solids	*NON-DETE	mg/L	
3/28/2001	385081	Ammonia (N)	0.181	mg/L	
3/28/2001	385081	Nitrate + Nitrite (N)	1.78	mg/L	
3/28/2001	385081	Nitrogen (Total	1.26	mg/L	
3/28/2001	385081	Nitrogen (Total)	3.04	mg/L	
3/28/2001	385081	Phosphorus (Total)	0.664	mg/L	
3/28/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/11/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
4/11/2001	385081	Nitrate + Nitrite (N)	0.70	mg/L	
4/11/2001	385081	Nitrogen (Total	1.09	mg/L	
4/11/2001	385081	Nitrogen (Total)	1.79	mg/L	
4/11/2001	385081	Phosphorus (Total)	0.335	mg/L	
4/11/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/16/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
4/16/2001	385081	Nitrate + Nitrite (N)	0.15	mg/L	
4/16/2001	385081	Nitrogen (Total	1.05	mg/L	
4/16/2001	385081	Nitrogen (Total)	1.20	mg/L	
4/16/2001	385081	Phosphorus (Total)	0.257	mg/L	

4/18/2001	385081	Nitrogen (Total	1.01	mg/L	
4/18/2001	385081	Nitrogen (Total)	1.06	mg/L	
4/18/2001	385081	Phosphorus (Total)	0.236	mg/L	
4/18/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/23/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
4/23/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
4/23/2001	385081	Nitrogen (Total	1.00	mg/L	
4/23/2001	385081	Nitrogen (Total)	1.02	mg/L	
4/23/2001	385081	Phosphorus (Total)	0.207	mg/L	
4/23/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/25/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
4/25/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
4/25/2001	385081	Nitrogen (Total	0.990	mg/L	
4/25/2001	385081	Nitrogen (Total)	1.01	mg/L	
4/25/2001	385081	Phosphorus (Total)	0.182	mg/L	
4/25/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/3/2001	385081	Ammonia (N)	0.034	mg/L	
4/3/2001	385081	Nitrate + Nitrite (N)	0.82	mg/L	
4/3/2001	385081	Nitrogen (Total	1.01	mg/L	
4/3/2001	385081	Nitrogen (Total)	1.83	mg/L	
4/3/2001	385081	Phosphorus (Total)	0.450	mg/L	
4/3/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/4/2001	385081	Ammonia (N)	0.031	mg/L	
4/4/2001	385081	Nitrate + Nitrite (N)	0.78	mg/L	
4/4/2001	385081	Nitrogen (Total	0.990	mg/L	
4/4/2001	385081	Nitrogen (Total)	1.77	mg/L	
4/4/2001	385081	Phosphorus (Total)	0.423	mg/L	
4/4/2001	385081	Suspended Solids	*NON-DETE	mg/L	
4/9/2001	385081	Ammonia (N)	0.039	mg/L	
4/9/2001	385081	Nitrate + Nitrite (N)	1.56	mg/L	
4/9/2001	385081	Nitrogen (Total	1.55	mg/L	
4/9/2001	385081	Nitrogen (Total)	3.11	mg/L	
4/9/2001	385081	Phosphorus (Total)	0.438	mg/L	
4/9/2001	385081	Suspended Solids	*NON-DETE	mg/L	

5/1/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
5/1/2001	385081	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/1/2001	385081	Nitrogen (Total	1.13	mg/L	
5/1/2001	385081	Nitrogen (Total)	1.15	mg/L	
5/1/2001	385081	Phosphorus (Total)	0.168	mg/L	
5/1/2001	385081	Suspended Solids	*NON-DETE	mg/L	
5/14/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
5/14/2001	385081	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/14/2001	385081	Nitrogen (Total	1.55	mg/L	
5/14/2001	385081	Nitrogen (Total)	1.57	mg/L	
5/14/2001	385081	Phosphorus (Total)	0.234	mg/L	
5/14/2001	385081	Suspended Solids	7.	mg/L	
5/16/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
5/16/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
5/16/2001	385081	Nitrogen (Total	1.64	mg/L	
5/16/2001	385081	Nitrogen (Total)	1.66	mg/L	
5/16/2001	385081	Phosphorus (Total)	0.285	mg/L	
5/16/2001	385081	Suspended Solids	*NON-DETE	mg/L	
5/2/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
5/2/2001	385081	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/2/2001	385081	Nitrogen (Total	1.18	mg/L	
5/2/2001	385081	Nitrogen (Total)	1.20	mg/L	
5/2/2001	385081	Phosphorus (Total)	0.159	mg/L	
5/2/2001	385081	Suspended Solids	*NON-DETE	mg/L	
5/21/2001	385081	Ammonia (N)	0.189	mg/L	
5/21/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
5/21/2001	385081	Nitrogen (Total	2.02	mg/L	
5/21/2001	385081	Nitrogen (Total)	2.04	mg/L	
5/21/2001	385081	Phosphorus (Total)	0.361	mg/L	
5/21/2001	385081	Suspended Solids	*NON-DETE	mg/L	
5/23/2001	385081	Ammonia (N)	0.037	mg/L	
5/23/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
5/23/2001	385081	Nitrogen (Total	2.00	mg/L	
5/23/2001	385081	Nitrogen (Total)	2.02	mg/L	

5/23/2001	385081	Phosphorus (Total)	0.337	mg/L	
5/23/2001	385081	Suspended Solids	33.	mg/L	
5/7/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
5/7/2001	385081	Nitrate + Nitrite (N)	0.21	mg/L	
5/7/2001	385081	Nitrogen (Total	1.64	mg/L	
5/7/2001	385081	Nitrogen (Total)	1.85	mg/L	
5/7/2001	385081	Phosphorus (Total)	0.360	mg/L	
5/7/2001	385081	Suspended Solids	5.	mg/L	
5/9/2001	385081	Ammonia (N)	*NON-DETE	mg/L	
5/9/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
5/9/2001	385081	Nitrogen (Total	1.41	mg/L	
5/9/2001	385081	Nitrogen (Total)	1.43	mg/L	
5/9/2001	385081	Phosphorus (Total)	0.230	mg/L	
5/9/2001	385081	Suspended Solids	*NON-DETE	mg/L	
6/7/2001	385081	Ammonia (N)	0.012	mg/L	
6/7/2001	385081	Nitrate + Nitrite (N)	0.02	mg/L	
6/7/2001	385081	Nitrogen (Total	1.48	mg/L	
6/7/2001	385081	Nitrogen (Total)	1.50	mg/L	
6/7/2001	385081	Phosphorus (Total)	0.111	mg/L	
6/7/2001	385081	Suspended Solids	21.	mg/L	
3/21/2001	385082	Ammonia (N)	0.175	mg/L	
3/21/2001	385082	Nitrate + Nitrite (N)	1.40	mg/L	
3/21/2001	385082	Nitrogen (Total	1.46	mg/L	
3/21/2001	385082	Nitrogen (Total)	2.86	mg/L	
3/21/2001	385082	Phosphorus (Total)	0.640	mg/L	
3/21/2001	385082	Suspended Solids	7.	mg/L	
3/26/2001	385082	Ammonia (N)	0.116	mg/L	
3/26/2001	385082	Nitrate + Nitrite (N)	1.59	mg/L	
3/26/2001	385082	Nitrogen (Total	1.35	mg/L	
3/26/2001	385082	Nitrogen (Total)	2.94	mg/L	
3/26/2001	385082	Phosphorus (Total)	0.666	mg/L	
3/26/2001	385082	Suspended Solids	*NON-DETE	mg/L	
3/28/2001	385082	Ammonia (N)	0.083	mg/L	
3/28/2001	385082	Nitrate + Nitrite (N)	1.37	mg/L	

3/28/2001	385082	Nitrogen (Total	1.16	mg/L	
3/28/2001	385082	Nitrogen (Total)	2.53	mg/L	
3/28/2001	385082	Phosphorus (Total)	0.542	mg/L	
3/28/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/11/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/11/2001	385082	Nitrate + Nitrite (N)	0.63	mg/L	
4/11/2001	385082	Nitrogen (Total	1.07	mg/L	
4/11/2001	385082	Nitrogen (Total)	1.70	mg/L	
4/11/2001	385082	Phosphorus (Total)	0.439	mg/L	
4/11/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/16/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/16/2001	385082	Nitrate + Nitrite (N)	0.03	mg/L	
4/16/2001	385082	Nitrogen (Total	0.980	mg/L	
4/16/2001	385082	Nitrogen (Total)	1.01	mg/L	
4/16/2001	385082	Phosphorus (Total)	0.352	mg/L	
4/16/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/18/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/18/2001	385082	Nitrate + Nitrite (N)	0.04	mg/L	
4/18/2001	385082	Nitrogen (Total	1.01	mg/L	
4/18/2001	385082	Nitrogen (Total)	1.05	mg/L	
4/18/2001	385082	Phosphorus (Total)	0.329	mg/L	
4/18/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/23/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/23/2001	385082	Nitrate + Nitrite (N)	0.03	mg/L	
4/23/2001	385082	Nitrogen (Total	0.966	mg/L	
4/23/2001	385082	Nitrogen (Total)	0.996	mg/L	
4/23/2001	385082	Phosphorus (Total)	0.253	mg/L	
4/23/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/25/2001	385082	Ammonia (N)	0.018	mg/L	
4/25/2001	385082	Nitrate + Nitrite (N)	0.03	mg/L	
4/25/2001	385082	Nitrogen (Total	0.990	mg/L	
4/25/2001	385082	Nitrogen (Total)	1.02	mg/L	
4/25/2001	385082	Phosphorus (Total)	0.283	mg/L	
4/25/2001	385082	Suspended Solids	*NON-DETE	mg/L	

4/3/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/3/2001	385082	Nitrate + Nitrite (N)	0.60	mg/L	
4/3/2001	385082	Nitrogen (Total	1.00	mg/L	
4/3/2001	385082	Nitrogen (Total)	1.60	mg/L	
4/3/2001	385082	Phosphorus (Total)	0.386	mg/L	
4/3/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/4/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/4/2001	385082	Nitrate + Nitrite (N)	0.46	mg/L	
4/4/2001	385082	Nitrogen (Total	1.00	mg/L	
4/4/2001	385082	Nitrogen (Total)	1.46	mg/L	
4/4/2001	385082	Phosphorus (Total)	0.367	mg/L	
4/4/2001	385082	Suspended Solids	*NON-DETE	mg/L	
4/9/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
4/9/2001	385082	Nitrate + Nitrite (N)	1.55	mg/L	
4/9/2001	385082	Nitrogen (Total	1.28	mg/L	
4/9/2001	385082	Nitrogen (Total)	2.83	mg/L	
4/9/2001	385082	Phosphorus (Total)	0.452	mg/L	
4/9/2001	385082	Suspended Solids	6.	mg/L	
5/1/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/1/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/1/2001	385082	Nitrogen (Total	1.06	mg/L	
5/1/2001	385082	Nitrogen (Total)	1.08	mg/L	
5/1/2001	385082	Phosphorus (Total)	0.234	mg/L	
5/1/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/14/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/14/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/14/2001	385082	Nitrogen (Total	1.52	mg/L	
5/14/2001	385082	Nitrogen (Total)	1.54	mg/L	
5/14/2001	385082	Phosphorus (Total)	0.271	mg/L	
5/14/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/16/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/16/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/16/2001	385082	Nitrogen (Total	1.39	mg/L	
5/16/2001	385082	Nitrogen (Total)	1.41	mg/L	

5/16/2001	385082	Phosphorus (Total)	0.338	mg/L	
5/16/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/2/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/2/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/2/2001	385082	Nitrogen (Total	1.10	mg/L	
5/2/2001	385082	Nitrogen (Total)	1.12	mg/L	
5/2/2001	385082	Phosphorus (Total)	0.248	mg/L	
5/2/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/21/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/21/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/21/2001	385082	Nitrogen (Total	1.40	mg/L	
5/21/2001	385082	Nitrogen (Total)	1.42	mg/L	
5/21/2001	385082	Phosphorus (Total)	0.361	mg/L	
5/21/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/23/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/23/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
5/23/2001	385082	Nitrogen (Total	1.18	mg/L	
5/23/2001	385082	Nitrogen (Total)	1.20	mg/L	
5/23/2001	385082	Phosphorus (Total)	0.297	mg/L	
5/23/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/7/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/7/2001	385082	Nitrate + Nitrite (N)	0.45	mg/L	
5/7/2001	385082	Nitrogen (Total	1.50	mg/L	
5/7/2001	385082	Nitrogen (Total)	1.95	mg/L	
5/7/2001	385082	Phosphorus (Total)	0.350	mg/L	
5/7/2001	385082	Suspended Solids	*NON-DETE	mg/L	
5/9/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
5/9/2001	385082	Nitrate + Nitrite (N)	0.02	mg/L	
5/9/2001	385082	Nitrogen (Total	1.38	mg/L	
5/9/2001	385082	Nitrogen (Total)	1.40	mg/L	
5/9/2001	385082	Phosphorus (Total)	0.302	mg/L	
5/9/2001	385082	Suspended Solids	*NON-DETE	mg/L	
6/11/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
6/11/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	

6/11/2001	385082	Nitrogen (Total	1.12	mg/L	
6/11/2001	385082	Nitrogen (Total)	1.14	mg/L	
6/11/2001	385082	Phosphorus (Total)	0.163	mg/L	
6/11/2001	385082	Suspended Solids	*NON-DETE	mg/L	
6/13/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
6/13/2001	385082	Nitrate + Nitrite (N)	0.02	mg/L	
6/13/2001	385082	Nitrogen (Total	1.14	mg/L	
6/13/2001	385082	Nitrogen (Total)	1.16	mg/L	
6/13/2001	385082	Phosphorus (Total)	0.183	mg/L	
6/13/2001	385082	Suspended Solids	*NON-DETE	mg/L	
6/18/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
6/18/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/18/2001	385082	Nitrogen (Total	1.47	mg/L	
6/18/2001	385082	Nitrogen (Total)	1.49	mg/L	
6/18/2001	385082	Phosphorus (Total)	0.275	mg/L	
6/18/2001	385082	Suspended Solids	*NON-DETE	mg/L	
6/20/2001	385082	Ammonia (N)	0.024	mg/L	
6/20/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/20/2001	385082	Nitrogen (Total	1.61	mg/L	
6/20/2001	385082	Nitrogen (Total)	1.63	mg/L	
6/20/2001	385082	Phosphorus (Total)	0.316	mg/L	
6/20/2001	385082	Suspended Solids	*NON-DETE	mg/L	
6/25/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
6/25/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/25/2001	385082	Nitrogen (Total	1.66	mg/L	
6/25/2001	385082	Nitrogen (Total)	1.68	mg/L	
6/25/2001	385082	Phosphorus (Total)	0.230	mg/L	
6/25/2001	385082	Suspended Solids	*NON-DETE	mg/L	
6/4/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
6/4/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/4/2001	385082	Nitrogen (Total	1.20	mg/L	
6/4/2001	385082	Nitrogen (Total)	1.22	mg/L	
6/4/2001	385082	Phosphorus (Total)	0.151	mg/L	
6/4/2001	385082	Suspended Solids	*NON-DETE	mg/L	

6/7/2001	385082	Ammonia (N)	*NON-DETE	mg/L	
6/7/2001	385082	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
6/7/2001	385082	Nitrogen (Total	1.11	mg/L	
6/7/2001	385082	Nitrogen (Total)	1.13	mg/L	
6/7/2001	385082	Phosphorus (Total)	0.124	mg/L	
6/7/2001	385082	Suspended Solids	*NON-DETE	mg/L	
3/21/2001	385083	Ammonia (N)	0.184	mg/L	
3/21/2001	385083	Nitrate + Nitrite (N)	1.22	mg/L	
3/21/2001	385083	Nitrogen (Total	1.55	mg/L	
3/21/2001	385083	Nitrogen (Total)	2.77	mg/L	
3/21/2001	385083	Phosphorus (Total)	0.676	mg/L	
3/21/2001	385083	Suspended Solids	7.	mg/L	
3/26/2001	385083	Ammonia (N)	0.117	mg/L	
3/26/2001	385083	Nitrate + Nitrite (N)	1.32	mg/L	
3/26/2001	385083	Nitrogen (Total	1.57	mg/L	
3/26/2001	385083	Nitrogen (Total)	2.89	mg/L	
3/26/2001	385083	Phosphorus (Total)	0.738	mg/L	
3/26/2001	385083	Suspended Solids	*NON-DETE	mg/L	
3/28/2001	385083	Ammonia (N)	0.057	ug/L	
3/28/2001	385083	Nitrate + Nitrite (N)	0.83	ug/L	
3/28/2001	385083	Nitrogen (Total	1.55	mg/L	
3/28/2001	385083	Nitrogen (Total)	2.38	mg/L	
3/28/2001	385083	Phosphorus (Total)	0.620	mg/L	
3/28/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/11/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/11/2001	385083	Nitrate + Nitrite (N)	0.84	mg/L	
4/11/2001	385083	Nitrogen (Total	1.47	mg/L	
4/11/2001	385083	Nitrogen (Total)	2.31	mg/L	
4/11/2001	385083	Phosphorus (Total)	0.407	mg/L	
4/11/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/16/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/16/2001	385083	Nitrate + Nitrite (N)	0.07	mg/L	
4/16/2001	385083	Nitrogen (Total	1.30	mg/L	
4/16/2001	385083	Nitrogen (Total)	1.37	mg/L	

4/16/2001	385083	Phosphorus (Total)	0.303	mg/L	
4/16/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/18/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/18/2001	385083	Nitrate + Nitrite (N)	0.06	mg/L	
4/18/2001	385083	Nitrogen (Total	1.36	mg/L	
4/18/2001	385083	Nitrogen (Total)	1.42	mg/L	
4/18/2001	385083	Phosphorus (Total)	0.356	mg/L	
4/18/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/23/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/23/2001	385083	Nitrate + Nitrite (N)	0.10	mg/L	
4/23/2001	385083	Nitrogen (Total	1.32	mg/L	
4/23/2001	385083	Nitrogen (Total)	1.42	mg/L	
4/23/2001	385083	Phosphorus (Total)	0.267	mg/L	
4/23/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/25/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/25/2001	385083	Nitrate + Nitrite (N)	0.09	mg/L	
4/25/2001	385083	Nitrogen (Total	1.23	mg/L	
4/25/2001	385083	Nitrogen (Total)	1.32	mg/L	
4/25/2001	385083	Phosphorus (Total)	0.265	mg/L	
4/25/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/3/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/3/2001	385083	Nitrate + Nitrite (N)	0.09	mg/L	
4/3/2001	385083	Nitrogen (Total	1.18	mg/L	
4/3/2001	385083	Nitrogen (Total)	1.27	mg/L	
4/3/2001	385083	Phosphorus (Total)	0.394	mg/L	
4/3/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/4/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/4/2001	385083	Nitrate + Nitrite (N)	0.08	mg/L	
4/4/2001	385083	Nitrogen (Total	1.15	mg/L	
4/4/2001	385083	Nitrogen (Total)	1.23	mg/L	
4/4/2001	385083	Phosphorus (Total)	0.366	mg/L	
4/4/2001	385083	Suspended Solids	*NON-DETE	mg/L	
4/9/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
4/9/2001	385083	Nitrate + Nitrite (N)	1.60	mg/L	

4/9/2001	385083	Nitrogen (Total	1.52	mg/L	
4/9/2001	385083	Nitrogen (Total)	3.12	mg/L	
4/9/2001	385083	Phosphorus (Total)	0.424	mg/L	
4/9/2001	385083	Suspended Solids	9.	mg/L	
5/1/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
5/1/2001	385083	Nitrate + Nitrite (N)	0.10	mg/L	
5/1/2001	385083	Nitrogen (Total	1.44	mg/L	
5/1/2001	385083	Nitrogen (Total)	1.54	mg/L	
5/1/2001	385083	Phosphorus (Total)	0.287	mg/L	
5/1/2001	385083	Suspended Solids	*NON-DETE	mg/L	
5/14/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
5/14/2001	385083	Nitrate + Nitrite (N)	0.06	mg/L	
5/14/2001	385083	Nitrogen (Total	1.88	mg/L	
5/14/2001	385083	Nitrogen (Total)	1.94	mg/L	
5/14/2001	385083	Phosphorus (Total)	0.438	mg/L	
5/14/2001	385083	Suspended Solids	*NON-DETE	mg/L	
5/16/2001	385083	Ammonia (N)	0.011	mg/L	
5/16/2001	385083	Nitrate + Nitrite (N)	0.04	mg/L	
5/16/2001	385083	Nitrogen (Total	1.88	ug/L	
5/16/2001	385083	Nitrogen (Total)	1.92	ug/L	
5/16/2001	385083	Phosphorus (Total)	0.508	mg/L	
5/16/2001	385083	Suspended Solids	*NON-DETE	mg/L	
5/2/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
5/2/2001	385083	Nitrate + Nitrite (N)	0.08	mg/L	
5/2/2001	385083	Nitrogen (Total	1.55	mg/L	
5/2/2001	385083	Nitrogen (Total)	1.63	mg/L	
5/2/2001	385083	Phosphorus (Total)	0.305	mg/L	
5/2/2001	385083	Suspended Solids	*NON-DETE	mg/L	
5/21/2001	385083	Ammonia (N)	0.012	mg/L	
5/21/2001	385083	Nitrate + Nitrite (N)	0.07	mg/L	
5/21/2001	385083	Nitrogen (Total	1.97	mg/L	
5/21/2001	385083	Nitrogen (Total)	2.04	mg/L	
5/21/2001	385083	Phosphorus (Total)	0.558	mg/L	
5/21/2001	385083	Suspended Solids	40.	mg/L	

5/23/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
5/23/2001	385083	Nitrate + Nitrite (N)	0.03	mg/L	
5/23/2001	385083	Nitrogen (Total	1.83	mg/L	
5/23/2001	385083	Nitrogen (Total)	1.86	mg/L	
5/23/2001	385083	Phosphorus (Total)	0.442	mg/L	1
5/29/2001	385083	Ammonia (N)	0.011	mg/L	1
5/29/2001	385083	Nitrate + Nitrite (N)	0.02	mg/L	1
5/29/2001	385083	Nitrogen (Total	2.04	mg/L	1
5/29/2001	385083	Nitrogen (Total)	2.06	mg/L	1
5/29/2001	385083	Phosphorus (Total)	0.362	mg/L	1
5/29/2001	385083	Suspended Solids	*NON-DETE	mg/L	2
5/30/2001	385083	Ammonia (N)	*NON-DETE	mg/L	2
5/30/2001	385083	Nitrate + Nitrite (N)	*NON-DETE	mg/L	2
5/30/2001	385083	Nitrogen (Total	2.05	mg/L	2
5/30/2001	385083	Nitrogen (Total)	2.07	mg/L	2
5/30/2001	385083	Phosphorus (Total)	0.380	mg/L	2
5/30/2001	385083	Suspended Solids	*NON-DETE	mg/L	4
5/7/2001	385083	Ammonia (N)	*NON-DETE	mg/L	4
5/7/2001	385083	Nitrate + Nitrite (N)	0.18	mg/L	4
5/7/2001	385083	Nitrogen (Total	1.75	mg/L	4
5/7/2001	385083	Nitrogen (Total)	1.93	mg/L	4
5/7/2001	385083	Phosphorus (Total)	0.449	mg/L	4
5/7/2001	385083	Suspended Solids	93.	ug/L	
5/9/2001	385083	Ammonia (N)	*NON-DETE	ug/L	
5/9/2001	385083	Nitrate + Nitrite (N)	0.03	mg/L	
5/9/2001	385083	Nitrogen (Total	1.53	mg/L	
5/9/2001	385083	Nitrogen (Total)	1.56	mg/L	
5/9/2001	385083	Phosphorus (Total)	0.318	mg/L	
5/9/2001	385083	Suspended Solids	*NON-DETE	mg/L	
6/11/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
6/11/2001	385083	Nitrate + Nitrite (N)	0.03	mg/L	
6/11/2001	385083	Nitrogen (Total	1.94	mg/L	
6/11/2001	385083	Nitrogen (Total)	1.97	mg/L	
6/11/2001	385083	Phosphorus (Total)	0.342	mg/L	

6/11/2001	385083	Suspended Solids	*NON-DETE	mg/L	
6/13/2001	385083	Ammonia (N)	0.026	mg/L	
6/13/2001	385083	Nitrate + Nitrite (N)	0.04	mg/L	
6/13/2001	385083	Nitrogen (Total	2.08	mg/L	
6/13/2001	385083	Nitrogen (Total)	2.12	mg/L	
6/13/2001	385083	Phosphorus (Total)	0.435	mg/L	
6/13/2001	385083	Suspended Solids	*NON-DETE	mg/L	
6/18/2001	385083	Ammonia (N)	*NON-DETE	mg/L	
6/18/2001	385083	Nitrate + Nitrite (N)	0.02	ug/L	
6/18/2001	385083	Nitrogen (Total	2.08	ug/L	
6/18/2001	385083	Nitrogen (Total)	2.10	mg/L	4
6/18/2001	385083	Phosphorus (Total)	0.555	mg/L	4
6/18/2001	385083	Suspended Solids	*NON-DETE	mg/L	4
6/20/2001	385083	Ammonia (N)	*NON-DETE	mg/L	4
6/20/2001	385083	Nitrate + Nitrite (N)	*NON-DETE	mg/L	4
6/20/2001	385083	Nitrogen (Total	2.00	mg/L	4
6/20/2001	385083	Nitrogen (Total)	2.02	mg/L	3
6/20/2001	385083	Phosphorus (Total)	0.650	mg/L	3
6/20/2001	385083	Suspended Solids	*NON-DETE	mg/L	3
6/25/2001	385083	Ammonia (N)	*NON-DETE	mg/L	3
6/25/2001	385083	Nitrate + Nitrite (N)	*NON-DETE	mg/L	3
6/25/2001	385083	Nitrogen (Total	1.84	mg/L	3
6/25/2001	385083	Nitrogen (Total)	1.86	mg/L	1
6/25/2001	385083	Phosphorus (Total)	0.466	mg/L	1
6/25/2001	385083	Suspended Solids	*NON-DETE	mg/L	1
6/4/2001	385083	Ammonia (N)	*NON-DETE	mg/L	1
6/4/2001	385083	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
6/4/2001	385083	Nitrogen (Total	2.05	mg/L	1
6/4/2001	385083	Nitrogen (Total)	2.07	mg/L	
6/4/2001	385083	Phosphorus (Total)	0.378	mg/L	
6/4/2001	385083	Suspended Solids	11.	mg/L	
6/7/2001	385083	Ammonia (N)	0.021	mg/L	
6/7/2001	385083	Nitrate + Nitrite (N)	0.21	mg/L	
6/7/2001	385083	Nitrogen (Total	1.93	mg/L	

6/7/2001	385083	Nitrogen (Total)	2.14	mg/L	1
6/7/2001	385083	Phosphorus (Total)	0.370	mg/L	1
6/7/2001	385083	Suspended Solids	*NON-DETE	mg/L	1
7/2/2001	385083	Ammonia (N)	0.055	mg/L	1
7/2/2001	385083	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
7/2/2001	385083	Nitrogen (Total	2.23	mg/L	1
7/2/2001	385083	Nitrogen (Total)	2.25	ug/L	
7/2/2001	385083	Phosphorus (Total)	0.612	ug/L	
7/2/2001	385083	Suspended Solids	*NON-DETE	mg/L	
1/9/2002	385094	Ammonia (N)	*NON-DETE	mg/L	
1/9/2002	385094	Dissolved	0.349	mg/L	
1/9/2002	385094	Nitrate + Nitrite (N)	0.08	mg/L	
1/9/2002	385094	Nitrogen (Total	1.52	mg/L	
1/9/2002	385094	Nitrogen (Total)	1.60	mg/L	
1/9/2002	385094	Phosphorus (Total)	0.386	mg/L	3
10/29/2001	385094	Ammonia (N)	0.035	mg/L	3
10/29/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	3
10/29/2001	385094	Nitrogen (Total	1.42	mg/L	3
10/29/2001	385094	Nitrogen (Total)	1.44	mg/L	3
10/29/2001	385094	Phosphorus (Total)	0.404	mg/L	3
2/7/2002	385094	Ammonia (N)	*NON-DETE	mg/L	4
2/7/2002	385094	Dissolved	0.364	mg/L	4
2/7/2002	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	4
2/7/2002	385094	Nitrogen (Total	1.73	mg/L	4
2/7/2002	385094	Nitrogen (Total)	1.75	mg/L	4
2/7/2002	385094	Phosphorus (Total)	0.438	mg/L	4
6/22/2001	385094	Ammonia (N)	0.010	ug/L	
6/22/2001	385094	Dissolved	0.376	ug/L	
6/22/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
6/22/2001	385094	Nitrogen (Total	1.25	mg/L	1
6/22/2001	385094	Nitrogen (Total)	1.27	mg/L	1
6/22/2001	385094	Phosphorus (Total)	0.439	mg/L	1
6/4/2001	385094	Ammonia (N)	*NON-DETE	mg/L	1
6/4/2001	385094	Dissolved	0.387	mg/L	1

6/4/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
6/4/2001	385094	Nitrogen (Total	1.30	mg/L	1
6/4/2001	385094	Nitrogen (Total)	1.32	mg/L	1
6/4/2001	385094	Phosphorus (Total)	0.419	mg/L	1
7/25/2001	385094	Ammonia (N)	0.042	mg/L	1
7/25/2001	385094	Dissolved	0.526	mg/L	1
7/25/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
7/25/2001	385094	Nitrogen (Total	1.50	mg/L	1
7/25/2001	385094	Nitrogen (Total)	1.52	mg/L	1
7/25/2001	385094	Phosphorus (Total)	0.609	mg/L	1
8/16/2001	385094	Ammonia (N)	0.023	mg/L	1
8/16/2001	385094	Dissolved	0.480	mg/L	1
8/16/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/16/2001	385094	Nitrogen (Total	1.57	mg/L	
8/16/2001	385094	Nitrogen (Total)	1.59	mg/L	
8/16/2001	385094	Phosphorus (Total)	0.600	mg/L	
8/2/2001	385094	Ammonia (N)	0.012	mg/L	
8/2/2001	385094	Dissolved	0.512	mg/L	
8/2/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	
8/2/2001	385094	Nitrogen (Total	1.53	mg/L	
8/2/2001	385094	Nitrogen (Total)	1.55	mg/L	
8/2/2001	385094	Phosphorus (Total)	0.617	mg/L	
8/29/2001	385094	Ammonia (N)	*NON-DETE	mg/L	1
8/29/2001	385094	Dissolved	0.542	mg/L	1
8/29/2001	385094	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
8/29/2001	385094	Nitrogen (Total	1.57	mg/L	1
8/29/2001	385094	Nitrogen (Total)	1.59	mg/L	1
8/29/2001	385094	Phosphorus (Total)	0.646	mg/L	2.5
9/20/2001	385094	Ammonia (N)	0.051	mg/L	2.5
9/20/2001	385094	Nitrate + Nitrite (N)	0.02	mg/L	2.5
9/20/2001	385094	Nitrogen (Total	1.42	mg/L	2.5
9/20/2001	385094	Nitrogen (Total)	1.44	mg/L	2.5
9/20/2001	385094	Phosphorus (Total)	0.518	mg/L	4.25
1/9/2002	389999	Ammonia (N)	*NON-DETE	mg/L	4.25

1/9/2002	389999	Dissolved	0.361	mg/L	4.25
1/9/2002	389999	Nitrate + Nitrite (N)	0.06	mg/L	4.25
1/9/2002	389999	Nitrogen (Total	1.62	mg/L	4.25
1/9/2002	389999	Nitrogen (Total)	1.68	ug/L	
1/9/2002	389999	Phosphorus (Total)	0.401	ug/L	
10/29/2001	389999	Ammonia (N)	0.039	mg/L	1
10/29/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
10/29/2001	389999	Nitrogen (Total	1.48	mg/L	1
10/29/2001	389999	Nitrogen (Total)	1.50	mg/L	1
10/29/2001	389999	Phosphorus (Total)	0.409	mg/L	1
2/7/2002	389999	Ammonia (N)	0.032	mg/L	1
2/7/2002	389999	Dissolved	0.362	mg/L	1
2/7/2002	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
2/7/2002	389999	Nitrogen (Total	1.75	mg/L	1
2/7/2002	389999	Nitrogen (Total)	1.77	mg/L	1
2/7/2002	389999	Phosphorus (Total)	0.424	mg/L	1
3/21/2001	389999	Ammonia (N)	0.153	mg/L	1
3/21/2001	389999	Nitrate + Nitrite (N)	1.51	mg/L	1
3/21/2001	389999	Nitrogen (Total	1.45	mg/L	1
3/21/2001	389999	Nitrogen (Total)	2.96	mg/L	1
3/21/2001	389999	Phosphorus (Total)	0.692	mg/L	
3/21/2001	389999	Suspended Solids	10.	mg/L	
3/26/2001	389999	Ammonia (N)	0.116	mg/L	
3/26/2001	389999	Nitrate + Nitrite (N)	1.60	mg/L	
3/26/2001	389999	Nitrogen (Total	1.33	mg/L	
3/26/2001	389999	Nitrogen (Total)	2.93	mg/L	
3/26/2001	389999	Phosphorus (Total)	0.664	mg/L	1
3/26/2001	389999	Suspended Solids	*NON-DETE	mg/L	1
4/16/2001	389999	Ammonia (N)	0.079	mg/L	1
4/16/2001	389999	Nitrate + Nitrite (N)	0.89	mg/L	1
4/16/2001	389999	Nitrogen (Total	1.26	mg/L	1
4/16/2001	389999	Nitrogen (Total)	2.15	mg/L	2
4/16/2001	389999	Phosphorus (Total)	0.399	mg/L	2
4/16/2001	389999	Suspended Solids	16.	mg/L	2

4/18/2001	389999	Ammonia (N)	*NON-DETE	mg/L	2
4/18/2001	389999	Nitrate + Nitrite (N)	0.06	mg/L	2
4/18/2001	389999	Nitrogen (Total	1.37	mg/L	3
4/18/2001	389999	Nitrogen (Total)	1.43	mg/L	3
4/18/2001	389999	Phosphorus (Total)	0.355	mg/L	3
4/18/2001	389999	Suspended Solids	*NON-DETE	mg/L	3
4/3/2001	389999	Ammonia (N)	0.046	mg/L	3
4/3/2001	389999	Nitrate + Nitrite (N)	0.31	ug/L	
4/3/2001	389999	Nitrogen (Total	1.06	ug/L	
4/3/2001	389999	Nitrogen (Total)	1.37	mg/L	1
4/3/2001	389999	Phosphorus (Total)	0.344	mg/L	1
4/3/2001	389999	Suspended Solids	*NON-DETE	mg/L	1
4/9/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
4/9/2001	389999	Nitrate + Nitrite (N)	2.51	mg/L	1
4/9/2001	389999	Nitrogen (Total	1.24	mg/L	1
4/9/2001	389999	Nitrogen (Total)	3.75	mg/L	1
4/9/2001	389999	Phosphorus (Total)	0.388	mg/L	1
4/9/2001	389999	Suspended Solids	13.	mg/L	1
5/1/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
5/1/2001	389999	Nitrate + Nitrite (N)	0.10	mg/L	1
5/1/2001	389999	Nitrogen (Total	1.43	mg/L	1
5/1/2001	389999	Nitrogen (Total)	1.53	mg/L	1
5/1/2001	389999	Phosphorus (Total)	0.285	mg/L	1
5/1/2001	389999	Suspended Solids	*NON-DETE	mg/L	1
5/14/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
5/14/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
5/14/2001	389999	Nitrogen (Total	1.49	mg/L	1
5/14/2001	389999	Nitrogen (Total)	1.51	mg/L	1
5/14/2001	389999	Phosphorus (Total)	0.273	mg/L	1
5/14/2001	389999	Suspended Solids	*NON-DETE	mg/L	1
5/16/2001	389999	Ammonia (N)	*NON-DETE	mg/L	2
5/16/2001	389999	Nitrate + Nitrite (N)	0.02	mg/L	2
5/16/2001	389999	Nitrogen (Total	1.65	mg/L	2
5/16/2001	389999	Nitrogen (Total)	1.67	mg/L	2

5/16/2001	389999	Phosphorus (Total)	0.288	mg/L	2
5/16/2001	389999	Suspended Solids	*NON-DETE	mg/L	2
5/23/2001	389999	Ammonia (N)	*NON-DETE	mg/L	3
5/23/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	3
5/23/2001	389999	Nitrogen (Total	1.44	mg/L	3
5/23/2001	389999	Nitrogen (Total)	1.46	mg/L	3
5/23/2001	389999	Phosphorus (Total)	0.307	mg/L	3
5/23/2001	389999	Suspended Solids	*NON-DETE	mg/L	3
5/30/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
5/30/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
5/30/2001	389999	Nitrogen (Total	2.09	mg/L	1
5/30/2001	389999	Nitrogen (Total)	2.11	mg/L	1
5/30/2001	389999	Phosphorus (Total)	0.391	mg/L	1
5/30/2001	389999	Suspended Solids	*NON-DETE	mg/L	1
6/11/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
6/11/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
6/11/2001	389999	Nitrogen (Total	1.14	mg/L	1
6/11/2001	389999	Nitrogen (Total)	1.16	mg/L	1
6/11/2001	389999	Phosphorus (Total)	0.163	mg/L	1
6/11/2001	389999	Suspended Solids	*NON-DETE	mg/L	1
6/18/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
6/18/2001	389999	Nitrate + Nitrite (N)	0.03	mg/L	1
6/18/2001	389999	Nitrogen (Total	1.24	mg/L	1
6/18/2001	389999	Nitrogen (Total)	1.27	mg/L	1
6/18/2001	389999	Phosphorus (Total)	0.395	mg/L	1
6/18/2001	389999	Suspended Solids	10.	mg/L	1
6/20/2001	389999	Ammonia (N)	0.042	mg/L	3
6/20/2001	389999	Nitrate + Nitrite (N)	0.04	mg/L	3
6/20/2001	389999	Nitrogen (Total	1.27	mg/L	3
6/20/2001	389999	Nitrogen (Total)	1.31	mg/L	3
6/20/2001	389999	Phosphorus (Total)	0.442	mg/L	3
6/20/2001	389999	Suspended Solids	7.	mg/L	3
6/4/2001	389999	Ammonia (N)	*NON-DETE	mg/L	2
6/4/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	2

6/4/2001	389999	Nitrogen (Total	2.06	mg/L	2
6/4/2001	389999	Nitrogen (Total)	2.08	mg/L	2
6/4/2001	389999	Phosphorus (Total)	0.374	mg/L	2
6/4/2001	389999	Suspended Solids	10.	mg/L	2
6/4/2001	389999	Ammonia (N)	*NON-DETE	mg/L	1
6/4/2001	389999	Dissolved	0.383	mg/L	1
6/4/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
6/4/2001	389999	Nitrogen (Total	1.29	mg/L	1
6/4/2001	389999	Nitrogen (Total)	1.31	mg/L	1
6/4/2001	389999	Phosphorus (Total)	0.424	mg/L	1
7/25/2001	389999	Ammonia (N)	0.049	mg/L	1
7/25/2001	389999	Dissolved	0.535	mg/L	1
7/25/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
7/25/2001	389999	Nitrogen (Total	1.54	mg/L	1
7/25/2001	389999	Nitrogen (Total)	1.56	mg/L	1
7/25/2001	389999	Phosphorus (Total)	0.621	mg/L	1
8/16/2001	389999	Chlorophyll A	27.0	mg/L	1
8/16/2001	389999	Chlorophyll B	2.00	mg/L	1
8/16/2001	389999	Ammonia (N)	0.016	mg/L	1
8/16/2001	389999	Dissolved	0.489	mg/L	1
8/16/2001	389999	Nitrate + Nitrite (N)	*NON-DETE	mg/L	1
8/16/2001	389999	Nitrogen (Total	1.55	mg/L	1
8/16/2001	389999	Nitrogen (Total)	1.57	mg/L	1
8/16/2001	389999	Phosphorus (Total)	0.601	mg/L	1
9/20/2001	389999	Ammonia (N)	0.053	mg/L	1
9/20/2001	389999	Nitrate + Nitrite (N)	0.02	mg/L	1
9/20/2001	389999	Nitrogen (Total	1.42	mg/L	1
9/20/2001	389999	Nitrogen (Total)	1.44	mg/L	1
9/20/2001	389999	Phosphorus (Total)	0.512	mg/L	
9/7/2001	389999	Ammonia (N)	0.081	mg/L	
9/7/2001	389999	Nitrate + Nitrite (N)	0.04	mg/L	
9/7/2001	389999	Nitrogen (Total	2.72	mg/L	
9/7/2001	389999	Nitrogen (Total)	2.76	mg/L	
9/7/2001	389999	Phosphorus (Total)	0.748	mg/L	

APPENDIX B2
Temperature and Oxygen Profiles

Deepest Area			
temp	depth	do	depth
4-Jun	4-Jun	4-Jun	4-Jun
17.10	0.5	11	0.5
17.10	3	11	3
17.70	6	11.17	6
17.60	9	11.07	9
17.50	12	10.65	12
16.60	15.5	7.32	15.5
22-Jun	22-Jun	22-Jun	22-Jun
20.80	0.5	11	0.5
20.80	3	10.97	3
20.40	4	10.7	4
20.00	5	10.15	5
19.90	6	10.03	6
19.90	7	10.12	7
19.70	8	9.85	8
19.20	9	9.3	9
19.00	10	8.32	10
18.70	11	7.49	11
18.70	12	6.92	12
18.60	13	6.04	13
18.40	14	5.18	14
24-Jul	24-Jul	24-Jul	24-Jul
27.30	0.5	10.16	0.5
27.30	2	10.16	2
27.20	3	9.66	3
27.20	4	8.61	4
27.20	5	8.36	5
27.00	6	7.9	6

26.60	7	6.6	7
26.20	8	5.7	8
26.00	9	4.2	9
25.90	10	4.07	10
25.90	11	3.4	11
25.50	12	2.29	12
25.00	13	0.92	13
2-Aug	2-Aug	2-Aug	2-Aug
26.5	0.50	10.5	0.50
26.5	1.00	10.54	1.00
26.3	2.00	8.89	2.00
26.1	3.00	8.13	3.00
26	4.00	7.91	4.00
26	5.00	7.93	5.00
26	6.00	7.96	6.00
25.8	7.00	6.83	7.00
25.3	8.00	4.31	8.00
25.2	9.00	3.84	9.00
24.9	10.00	2.3	10.00
24.7	11.00	1.27	11.00
16-Aug	16-Aug	16-Aug	16-Aug
22.7	0.50	7.7	0.50
22.7	1.00	7.7	1.00
22.7	2.00	7.37	2.00
22.7	3.00	7.48	3.00
22.7	4.00	7.3	4.00
22.7	5.00	7.75	5.00
22.7	6.00	7.99	6.00
22.7	7.00	7.46	7.00
22.6	8.00	7.15	8.00
22.6	9.00	7.05	9.00
22.6	10.00	6.99	10.00
22.6	11.00	6.92	11.00
22.6	12.00	7.06	12.00
22.6	13.00	7.01	13.00
29-Aug	29-Aug	29-Aug	29-Aug
23.4	0.50	4.52	0.50

23.4	1.00	4.52	1.00
23.4	2.00	4.41	2.00
23.4	3.00	4.21	3.00
23.4	4.00	4.15	4.00
23.4	5.00	4.12	5.00
23.4	6.00	4.11	6.00
23.4	7.00	4.22	7.00
23.4	8.00	4.19	8.00
23.4	9.00	4.07	9.00
23.3	10.00	3.53	10.00
23.3	11.00	3.01	11.00
23.2	12.00	2.72	12.00
23.2	13.00	2.49	13.00
23.1	14	1.07	14
23	15	0.48	15
20-Sep	20-Sep	20-Sep	20-Sep
15.7	0.50	7.42	0.50
15.7	1.00	7.42	1.00
15.7	2.00	7.48	2.00
15.7	3.00	7.46	3.00
15.7	4.00	7.38	4.00
15.6	5.00	7.27	5.00
15.6	6.00	7.18	6.00
15.6	7.00	7.27	7.00
15.6	8.00	7.26	8.00
15.6	9.00	7.18	9.00
15.6	10.00	7.15	10.00
15.6	11.00	7.15	11.00
15.6	12.00	7.15	12.00
15.6	13.00	7.1	13.00
29-Oct	29-Oct	29-Oct	29-Oct
4.2	0.50	14.6	0.50
4.2	1.00	14.67	1.00
3.8	2.00	14.8	2.00
3.8	3.00	15.02	3.00
3.8	4.00	14.36	4.00
3.8	5.00	14.32	5.00
3.8	6.00	14.28	6.00
3.8	7.00	14	7.00

3.8	8.00	13.65	8.00
3.8	9.00	13.88	9.00
3.8	10.00	13.71	10.00
9-Jan	9-Jan	9-Jan	9-Jan
2	0.50	8.42	0.50
2.5	3.00	8.42	3.00
2	6.00	7.58	6.00
2.1	9.00	7.12	9.00
2.3	12.00	4.8	12.00
2.3	13.00	1.24	13.00
Mid Lake			
temp	depth	do	depth
4-Jun	4-Jun	4-Jun	4-Jun
18.30	1	11.3	1
18.30	3	11.3	3
18.30	4	11.25	4
18.20	5	11.42	5
18.20	6	11.36	6
18.20	7	11.42	7
17.60	8	9.59	8
17.00	9	8.9	9
16.80	10	7.65	10
16.50	11	7.55	11
16.30	12	7.08	12
25-Jul	25-Jul	25-Jul	25-Jul
25.60	1.00	7.2	1.00
25.60	3.00	7.2	3.00
25.50	6.00	6.09	6.00
25.20	9.00	4.79	9.00
25.10	11.00	4.18	11.00
2-Aug	2-Aug	2-Aug	2-Aug
26.70	1.00	9.9	1.00
26.70	3.00	9.9	3.00
26.50	6.00	9.55	6.00
25.50	9.00	5.18	9.00
25.30	12.00	3.27	12.00

16-Aug	16-Aug	16-Aug	16-Aug
22.80	1.00	7.63	1.00
22.80	3.00	7.63	3.00
22.80	6.00	7.51	6.00
22.70	9.00	6.35	9.00
22.60	12.00	7.12	12.00
29-Aug	29-Aug	29-Aug	29-Aug
23.60	1.00	5.54	1.00
23.60	3.00	5.54	3.00
23.60	6.00	5.54	6.00
23.50	9.00	5.25	9.00
23.50	12.00	2.88	12.00
23.00	14.00	1.28	14.00
20-Sep	20-Sep	20-Sep	20-Sep
16.00	1.00	8.12	1.00
16.00	3.00	8.12	3.00
15.90	6.00	7.76	6.00
15.60	9.00	7.42	9.00
9-Jan	9-Jan	9-Jan	9-Jan
1.80	1.00	9.91	1.00
1.80	3.00	9.91	3.00
2.00	6.00	9.02	6.00
1.90	9.00	11.38	9.00

Inlet Area

temp	depth	do	depth
4-Jun	4-Jun	4-Jun	4-Jun
17.70	0.5	10.9	0.5
17.70	3	10.92	3
17.30	6	10.33	6
17.10	9	9.52	9
25-Jul	25-Jul	25-Jul	25-Jul
25.60	0.5	7	0.5
25.60	3	7.06	3
25.50	6	6.21	6
25.00	9	3.52	9

2-Aug	2-Aug	2-Aug	2-Aug
26.70	0.5	10.46	0.5
26.70	3	10.46	3
25.50	6	5.72	6
25.30	9	3.21	9
16-Aug	16-Aug	16-Aug	16-Aug
23.00	0.5	7.74	0.5
23.10	3	7.74	3
22.90	6	7.36	6
22.40	9	6.47	9
22.40	11	6.23	11
29-Aug	29-Aug	29-Aug	29-Aug
23.80	0.5	5.98	0.5
23.80	3	5.98	3
23.60	6	5.24	6
23.20	9	4.56	9
22.40	13	1.68	13
20-Sep	20-Sep	20-Sep	20-Sep
16.20	0.5	9.54	0.5
16.20	3	9.54	3
16.10	6	8.65	6
15.20	9	5.92	9
9-Jan	9-Jan	9-Jan	9-Jan
1.80	0.5	9.58	0.5
1.70	3	8.93	3
1.70	6	10.35	6
1.90	9	10.63	9
2.40	12	10.26	12

APPENDIX C
FLUX FILES

APPENDIX C1
Flux Files for Site 385083 (Elm River)

Elm R. Inlet Pheasant Lk 2001 VAR=nh3-4 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	143	7	7	4.4	.246	1.224	.671	.646
2	39	10	10	18.1	3.736	4.091	-.194	.630
3	43	12	12	77.5	14.531	14.257	.623	.508
***	225	29	29	100.0	3.581	7.606		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 3.581 HM3/YR
TOTAL FLOW VOLUME = 2.21 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	75.0	121.8	.3458E+04	34.01	.483
2 Q WTD C	69.1	112.2	.3723E+04	31.33	.544
3 IJC	68.7	111.5	.3882E+04	31.12	.559
4 REG-1	69.4	112.7	.6363E+04	31.46	.708
5 REG-2	68.1	110.6	.8123E+04	30.89	.815
6 REG-3	68.2	110.8	.1231E+05	30.93	1.002

Elm R. Inlet Pheasant Lk 2001 VAR=no2 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	143	7	7	4.4	.246	1.224	1.754	.268
2	39	10	10	18.1	3.736	4.091	1.820	.021
3	43	12	12	77.5	14.531	14.257	.983	.252
***	225	29	29	100.0	3.581	7.606		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 3.581 HM3/YR
TOTAL FLOW VOLUME = 2.21 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1222.8	1985.1	.7573E+06	554.31	.438
2 Q WTD C	1223.0	1985.3	.5386E+06	554.37	.370
3 IJC	1259.8	2045.1	.6208E+06	571.07	.385
4 REG-1	1239.3	2011.9	.7293E+06	561.79	.424
5 REG-2	1193.3	1937.2	.4831E+06	540.93	.359
6 REG-3	1506.8	2446.1	.2408E+07	683.05	.634

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Elm R. Inlet Pheasant Lk 2001     VAR=tn        METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
 1       143   7   7   4.4         .246        1.224        .004   .945
 2        39  10  10  18.1        3.736        4.091       -.184   .122
 3        43  12  12  77.5       14.531       14.257        .312   .166
***      225  29  29 100.0        3.581        7.606

FLOW STATISTICS
FLOW DURATION =     225.0 DAYS  =   .616 YEARS
MEAN FLOW RATE =     3.581 HM3/YR
TOTAL FLOW VOLUME =       2.21 HM3
FLOW DATE RANGE   = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
1 AV LOAD         5367.8         8713.7      .2246E+07    2433.20    .172
2 Q WTD C         4564.7         7410.0      .7117E+06    2069.15    .114
3 IJC             4602.8         7471.8      .8129E+06    2086.41    .121
4 REG-1           4598.0         7464.1      .7812E+06    2084.26    .118
5 REG-2           4560.8         7403.7      .6097E+06    2067.40    .105
6 REG-3           4587.3         7446.7      .7958E+06    2079.40    .120

Elm R. Inlet Pheasant Lk 2001     VAR=tp        METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
 1       143   7   7   4.4         .246        1.224       -.120   .688
 2        39  10  10  18.1        3.736        4.091       -.536   .060
 3        43  12  12  77.5       14.531       14.257        .051   .817
***      225  29  29 100.0        3.581        7.606

FLOW STATISTICS
FLOW DURATION =     225.0 DAYS  =   .616 YEARS
MEAN FLOW RATE =     3.581 HM3/YR
TOTAL FLOW VOLUME =       2.21 HM3
FLOW DATE RANGE   = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
1 AV LOAD         1126.2         1828.2      .5435E+05     510.50    .128
2 Q WTD C          968.7         1572.5      .2033E+05     439.11    .091
3 IJC              966.7         1569.3      .2022E+05     438.21    .091
4 REG-1            980.7         1591.9      .2472E+05     444.53    .099
5 REG-2            978.6         1588.6      .2324E+05     443.58    .096
6 REG-3            989.0         1605.4      .2954E+05     448.29    .107
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Elm R. Inlet Pheasant Lk 2001 VAR=tss METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	143	7	7	4.4	.246	1.224	1.377	.496
2	39	10	10	18.1	3.736	4.091	-1.659	.091
3	43	12	12	77.5	14.531	14.257	.649	.012
***	225	29	29	100.0	3.581	7.606		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 3.581 HM3/YR
TOTAL FLOW VOLUME = 2.21 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	18368.8	29818.6	.1709E+09	8326.46	.438
2 Q WTD C	11415.0	18530.4	.2148E+08	5174.37	.250
3 IJC	11610.8	18848.2	.2361E+08	5263.13	.258
4 REG-1	10973.2	17813.2	.1738E+08	4974.09	.234
5 REG-2	11260.7	18279.9	.1611E+08	5104.42	.220
6 REG-3	10425.9	16924.6	.1479E+08	4725.99	.227

APPENDIX C2
Flux Files for Site 385082 (Northwest Tributary)

NW Trib to Pheasant Lake 2001 VAR=nh3 METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	164	12	12	13.1	.450	1.726	-.613	.154
2	61	17	17	86.9	8.040	9.041	-.473	.157
***	225	29	29	100.0	2.508	6.014		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 2.508 HM3/YR
TOTAL FLOW VOLUME = 1.54 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	30.0	48.7	.2052E+03	19.43	.294
2 Q WTD C	17.5	28.5	.1008E+03	11.36	.353
3 IJC	16.9	27.4	.8438E+02	10.92	.336
4 REG-1	23.2	37.6	.1720E+03	15.01	.349
5 REG-2	20.2	32.9	.1240E+03	13.10	.339
6 REG-3	17.6	28.5	.9230E+02	11.38	.337

NW Trib to Pheasant Lake 2001 VAR=no2 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	164	12	12	13.1	.450	1.726	.529	.397
2	61	17	17	86.9	8.040	9.041	.508	.244
***	225	29	29	100.0	2.508	6.014		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 2.508 HM3/YR
TOTAL FLOW VOLUME = 1.54 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	871.2	1414.2	.7388E+06	563.96	.608
2 Q WTD C	704.3	1143.4	.4941E+06	455.95	.615
3 IJC	744.7	1208.8	.6243E+06	482.05	.654
4 REG-1	650.4	1055.8	.4584E+06	421.03	.641
5 REG-2	638.4	1036.4	.3748E+06	413.29	.591
6 REG-3	580.9	942.9	.3223E+06	376.01	.602

NW Trib to Pheasant Lake 2001   VAR=tn   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	164	12	12	13.1	.450	1.726	-.031	.519
2	61	17	17	86.9	8.040	9.041	.008	.934
***	225	29	29	100.0	2.508	6.014		

FLOW STATISTICS
FLOW DURATION =   225.0 DAYS =   .616 YEARS
MEAN FLOW RATE =   2.508 HM3/YR
TOTAL FLOW VOLUME =   1.54 HM3
FLOW DATE RANGE   = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	4605.0	7475.5	.2697E+07	2981.04	.220
2 Q WTD C	3075.6	4992.8	.5669E+06	1991.00	.151
3 IJC	3115.0	5056.7	.7188E+06	2016.49	.168
4 REG-1	3091.2	5018.1	.6178E+06	2001.09	.157
5 REG-2	3068.6	4981.4	.6223E+06	1986.45	.158
6 REG-3	2908.6	4721.7	.2959E+06	1882.90	.115

NW Trib to Pheasant Lake 2001   VAR=tp   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	164	12	12	13.1	.450	1.726	-.116	.269
2	61	17	17	86.9	8.040	9.041	-.175	.053
***	225	29	29	100.0	2.508	6.014		

FLOW STATISTICS
FLOW DURATION =   225.0 DAYS =   .616 YEARS
MEAN FLOW RATE =   2.508 HM3/YR
TOTAL FLOW VOLUME =   1.54 HM3
FLOW DATE RANGE   = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	926.4	1503.8	.5585E+05	599.67	.157
2 Q WTD C	597.2	969.4	.4913E+04	386.58	.072
3 IJC	596.0	967.5	.5640E+04	385.83	.078
4 REG-1	623.4	1012.0	.6407E+04	403.57	.079
5 REG-2	612.3	993.9	.8600E+04	396.34	.093
6 REG-3	599.3	972.9	.5966E+04	387.97	.079

NW Trib to Pheasant Lake 2001 VAR=tss METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	164	12	12	13.1	.450	1.726	.185	.726
2	61	17	17	86.9	8.040	9.041	.149	.242
***	225	29	29	100.0	2.508	6.014		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 2.508 HM3/YR
TOTAL FLOW VOLUME = 1.54 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010702

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	17273.1	28040.0	.1267E+09	11181.65	.401
2 Q WTD C	8331.9	13525.4	.1688E+08	5393.60	.304
3 IJC	8518.5	13828.4	.1936E+08	5514.44	.318
4 REG-1	7595.3	12329.7	.4839E+09	4916.79	1.784
5 REG-2	8303.1	13478.7	.1025E+10	5374.96	2.376
6 REG-3	6917.7	11229.7	.1273E+08	4478.12	.318

APPENDIX C3
Flux Files for Site 385081 (West Northwest Tributary)

WNW Trib to Pheasant Lake 2001 VAR=nh3-4 METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	137	3	3	2.4	.195	1.835	-9.852	.260
2	37	3	3	20.3	6.168	7.497	-3.843	.399
3	51	14	14	77.4	17.089	17.247	-2.413	.111
***	225	20	20	100.0	5.007	13.472		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 5.007 HM3/YR
TOTAL FLOW VOLUME = 3.08 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010607

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	189.9	308.3	.1436E+05	61.58	.389
2 Q WTD C	153.5	249.2	.1264E+05	49.78	.451
3 IJC	149.9	243.3	.1218E+05	48.61	.454
4 REG-1	197.2	320.1	.1432E+05	63.94	.374
5 REG-2	249.3	404.7	.2175E+05	80.83	.364
6 REG-3	205.4	333.5	.1581E+07	66.60	3.770

WNW Trib to Pheasant Lake 2001 VAR=no2 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	137	3	3	2.4	.195	1.835	-1.621	.417
2	37	3	3	20.3	6.168	7.497	2.136	.449
3	51	14	14	77.4	17.089	17.247	-.754	.707
***	225	20	20	100.0	5.007	13.472		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 5.007 HM3/YR
TOTAL FLOW VOLUME = 3.08 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010607

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1604.0	2603.8	.5242E+06	520.08	.278
2 Q WTD C	1575.8	2558.1	.5651E+06	510.95	.294
3 IJC	1566.1	2542.4	.5626E+06	507.81	.295
4 REG-1	1580.8	2566.2	.7359E+06	512.57	.334
5 REG-2	1580.2	2565.2	.7961E+06	512.38	.348
6 REG-3	4526.6	7348.2	.1670E+08	1467.72	.556

WNW Trib to Pheasant Lake 2001   VAR=tn   METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	137	3	3	2.4	.195	1.835	-.689	.128
2	37	3	3	20.3	6.168	7.497	-1.267	.287
3	51	14	14	77.4	17.089	17.247	-.502	.247
***	225	20	20	100.0	5.007	13.472		

FLOW STATISTICS
FLOW DURATION =   225.0 DAYS =   .616 YEARS
MEAN FLOW RATE =   5.007 HM3/YR
TOTAL FLOW VOLUME =   3.08 HM3
FLOW DATE RANGE   = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010607

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	6838.1	11100.6	.9409E+06	2217.23	.087
2 Q WTD C	5552.0	9012.8	.1035E+07	1800.22	.113
3 IJC	5512.6	8948.8	.1021E+07	1787.44	.113
4 REG-1	5831.2	9466.0	.1121E+07	1890.73	.112
5 REG-2	5828.5	9461.6	.1188E+07	1889.86	.115
6 REG-3	5921.5	9612.6	.1387E+07	1920.03	.123

WNW Trib to Pheasant Lake 2001   VAR=tp   METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	137	3	3	2.4	.195	1.835	-1.102	.047
2	37	3	3	20.3	6.168	7.497	-.592	.741
3	51	14	14	77.4	17.089	17.247	-.285	.634
***	225	20	20	100.0	5.007	13.472		

FLOW STATISTICS
FLOW DURATION =   225.0 DAYS =   .616 YEARS
MEAN FLOW RATE =   5.007 HM3/YR
TOTAL FLOW VOLUME =   3.08 HM3
FLOW DATE RANGE   = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010607

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1264.7	2053.1	.3923E+05	410.08	.096
2 Q WTD C	1049.2	1703.2	.4473E+05	340.20	.124
3 IJC	1043.0	1693.1	.4298E+05	338.18	.122
4 REG-1	1075.5	1745.8	.6310E+05	348.71	.144
5 REG-2	1074.1	1743.7	.7003E+05	348.28	.152
6 REG-3	1146.5	1861.1	.9627E+05	371.74	.167

WNW Trib to Pheasant Lake 2001 VAR=tss METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	137	3	3	2.4	.195	1.835	2.408	.417
2	37	3	3	20.3	6.168	7.497	-4.955	.399
3	51	14	14	77.4	17.089	17.247	-1.143	.043
***	225	20	20	100.0	5.007	13.472		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = 5.007 HM3/YR
TOTAL FLOW VOLUME = 3.08 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20010607

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	19880.0	32271.8	.1025E+09	6445.98	.314
2 Q WTD C	15765.8	25593.1	.8584E+08	5111.98	.362
3 IJC	15049.1	24429.6	.6376E+08	4879.58	.327
4 REG-1	26337.3	42754.2	.6392E+09	8539.73	.591
5 REG-2	29055.0	47166.0	.1976E+10	9420.95	.942
6 REG-3	66827.1	108482.6	.8437E+13	21668.32	26.776

APPENDIX C4
Flux Files for Site 385080 (West Tributary)

West Trib to Pheasant Lake 2001   VAR=NH3-4   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	179	5	5	4.2	.038	.160	-.234	.560
2	46	13	13	95.8	3.416	3.161	.371	.731
***	225	18	18	100.0	.729	2.327		

FLOW STATISTICS

FLOW DURATION =   225.0 DAYS =   .616 YEARS

MEAN FLOW RATE =   .729 HM3/YR

TOTAL FLOW VOLUME =   .45 HM3

FLOW DATE RANGE   = 20010320 TO 20011030

SAMPLE DATE RANGE = 20010321 TO 20011010

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	22.4	36.3	.2628E+03	49.83	.446
2 Q WTD C	23.8	38.6	.3053E+03	52.97	.453
3 IJC	23.7	38.6	.3213E+03	52.90	.465
4 REG-1	24.5	39.8	.7040E+03	54.60	.667
5 REG-2	24.9	40.4	.2466E+04	55.46	1.229
6 REG-3	30.0	48.7	.2782E+04	66.89	1.082

West Trib to Pheasant Lake 2001   VAR=NO2   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	179	5	5	4.2	.038	.160	-.290	.560
2	46	13	13	95.8	3.416	3.161	1.922	.069
***	225	18	18	100.0	.729	2.327		

FLOW STATISTICS

FLOW DURATION =   225.0 DAYS =   .616 YEARS

MEAN FLOW RATE =   .729 HM3/YR

TOTAL FLOW VOLUME =   .45 HM3

FLOW DATE RANGE   = 20010320 TO 20011030

SAMPLE DATE RANGE = 20010321 TO 20011010

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	392.2	636.8	.7564E+05	873.73	.432
2 Q WTD C	422.2	685.4	.5883E+05	940.44	.354
3 IJC	435.2	706.4	.6564E+05	969.34	.363
4 REG-1	490.4	796.0	.7363E+05	1092.29	.341
5 REG-2	557.0	904.3	.1558E+06	1240.81	.436
6 REG-3	855.8	1389.2	.5737E+06	1906.18	.545

West Trib to Pheasant Lake 2001 VAR=TN METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	179	5	5	4.2	.038	.160	.006	.957
2	46	13	13	95.8	3.416	3.161	.850	.004
***	225	18	18	100.0	.729	2.327		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = .729 HM3/YR
TOTAL FLOW VOLUME = .45 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20011010

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	977.0	1585.9	.1585E+06	2176.17	.251
2 Q WTD C	968.1	1571.5	.6315E+05	2156.38	.160
3 IJC	983.0	1595.7	.6869E+05	2189.63	.164
4 REG-1	1032.3	1675.8	.3527E+05	2299.49	.112
5 REG-2	1086.2	1763.2	.4335E+05	2419.42	.118
6 REG-3	1091.7	1772.2	.4428E+05	2431.82	.119

West Trib to Pheasant Lake 2001 VAR=TP METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	179	5	5	4.2	.038	.160	-.013	.931
2	46	13	13	95.8	3.416	3.161	.549	.115
***	225	18	18	100.0	.729	2.327		

FLOW STATISTICS
FLOW DURATION = 225.0 DAYS = .616 YEARS
MEAN FLOW RATE = .729 HM3/YR
TOTAL FLOW VOLUME = .45 HM3
FLOW DATE RANGE = 20010320 TO 20011030
SAMPLE DATE RANGE = 20010321 TO 20011010

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	168.6	273.7	.3244E+04	375.53	.208
2 Q WTD C	166.2	269.8	.1421E+04	370.18	.140
3 IJC	167.1	271.2	.1405E+04	372.11	.138
4 REG-1	173.3	281.3	.2242E+04	386.03	.168
5 REG-2	178.4	289.5	.6003E+04	397.28	.268
6 REG-3	184.5	299.6	.3898E+04	411.06	.208

West Trib to Pheasant Lake 2001 VAR=TSS METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	179	5	5	4.2	.038	.160	-.349	.494
2	46	13	13	95.8	3.416	3.161	.867	.365
***	225	18	18	100.0	.729	2.327		

FLOW STATISTICS

FLOW DURATION = 225.0 DAYS = .616 YEARS

MEAN FLOW RATE = .729 HM3/YR

TOTAL FLOW VOLUME = .45 HM3

FLOW DATE RANGE = 20010320 TO 20011030

SAMPLE DATE RANGE = 20010321 TO 20011010

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	9587.6	15563.9	.5792E+08	21356.26	.489
2 Q WTD C	10095.7	16388.8	.6305E+08	22488.16	.484
3 IJC	10164.8	16500.9	.6610E+08	22642.06	.493
4 REG-1	10837.0	17592.0	.1192E+09	24139.21	.621
5 REG-2	11339.2	18407.3	.2295E+09	25257.93	.823
6 REG-3	11972.6	19435.5	.2643E+09	26668.73	.836

APPENDIX C5
Flux Files for Site 380017 (Pheasant Lake Outlet)

Outlet Pheasant Lake 2001 VAR=nh3-4 METHOD= 3 IJC

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	154	12	12	27.9	4.332	4.263	8.866	.027
2	36	8	8	18.9	12.545	11.218	-.513	.774
3	33	11	11	53.1	38.428	41.110	.421	.684
***	223	31	31	100.0	10.703	19.133		

FLOW STATISTICS
FLOW DURATION = 223.0 DAYS = .611 YEARS
MEAN FLOW RATE = 10.703 HM3/YR
TOTAL FLOW VOLUME = 6.53 HM3
FLOW DATE RANGE = 20010322 TO 20011030
SAMPLE DATE RANGE = 20010326 TO 20010907

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	541.4	886.7	.4506E+05	82.84	.239
2 Q WTD C	529.2	866.8	.2867E+05	80.99	.195
3 IJC	531.0	869.8	.2746E+05	81.26	.191
4 REG-1	526.6	862.5	.4403E+05	80.58	.243
5 REG-2	493.4	808.1	.5096E+05	75.50	.279
6 REG-3	900.6	1475.1	.3237E+06	137.82	.386

Outlet Pheasant Lake 2001 VAR=no2 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	154	12	12	27.9	4.332	4.263	2.876	.211
2	36	8	8	18.9	12.545	11.218	1.116	.494
3	33	11	11	53.1	38.428	41.110	.669	.543
***	223	31	31	100.0	10.703	19.133		

FLOW STATISTICS
FLOW DURATION = 223.0 DAYS = .611 YEARS
MEAN FLOW RATE = 10.703 HM3/YR
TOTAL FLOW VOLUME = 6.53 HM3
FLOW DATE RANGE = 20010322 TO 20011030
SAMPLE DATE RANGE = 20010326 TO 20010907

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	3209.3	5256.5	.1628E+07	491.11	.243
2 Q WTD C	3061.2	5014.0	.6042E+06	468.45	.155
3 IJC	3094.3	5068.1	.6200E+06	473.50	.155
4 REG-1	2992.5	4901.3	.1832E+07	457.92	.276
5 REG-2	2803.8	4592.3	.5760E+07	429.05	.523
6 REG-3	6977.8	11428.8	.3794E+08	1067.78	.539

Outlet Pheasant Lake 2001 VAR=tn METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	154	12	12	27.9	4.332	4.263	.739	.254
2	36	8	8	18.9	12.545	11.218	.299	.197
3	33	11	11	53.1	38.428	41.110	.128	.573
***	223	31	31	100.0	10.703	19.133		

FLOW STATISTICS
FLOW DURATION = 223.0 DAYS = .611 YEARS
MEAN FLOW RATE = 10.703 HM3/YR
TOTAL FLOW VOLUME = 6.53 HM3
FLOW DATE RANGE = 20010322 TO 20011030
SAMPLE DATE RANGE = 20010326 TO 20010907

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	12393.1	20298.6	.1154E+08	1896.47	.167
2 Q WTD C	12128.2	19864.7	.1383E+07	1855.93	.059
3 IJC	12214.8	20006.5	.1516E+07	1869.18	.062
4 REG-1	12163.9	19923.2	.1743E+07	1861.40	.066
5 REG-2	12067.9	19765.9	.1788E+07	1846.70	.068
6 REG-3	12207.1	19994.0	.1649E+07	1868.01	.064

Outlet Pheasant Lake 2001 VAR=tp METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	154	12	12	27.9	4.332	4.263	1.010	.158
2	36	8	8	18.9	12.545	11.218	.170	.477
3	33	11	11	53.1	38.428	41.110	-.036	.856
***	223	31	31	100.0	10.703	19.133		

FLOW STATISTICS
FLOW DURATION = 223.0 DAYS = .611 YEARS
MEAN FLOW RATE = 10.703 HM3/YR
TOTAL FLOW VOLUME = 6.53 HM3
FLOW DATE RANGE = 20010322 TO 20011030
SAMPLE DATE RANGE = 20010326 TO 20010907

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2926.7	4793.6	.3608E+06	447.86	.125
2 Q WTD C	2888.4	4730.9	.5418E+05	442.00	.049
3 IJC	2892.2	4737.2	.5425E+05	442.59	.049
4 REG-1	2915.8	4775.8	.9034E+05	446.19	.063
5 REG-2	2914.9	4774.2	.1014E+06	446.05	.067
6 REG-3	2931.5	4801.5	.9533E+05	448.59	.064

Outlet Pheasant Lake 2001 VAR=tss METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	154	12	12	27.9	4.332	4.263	3.113	.036
2	36	8	8	18.9	12.545	11.218	-.151	.835
3	33	11	11	53.1	38.428	41.110	.588	.307
***	223	31	31	100.0	10.703	19.133		

FLOW STATISTICS
FLOW DURATION = 223.0 DAYS = .611 YEARS
MEAN FLOW RATE = 10.703 HM3/YR
TOTAL FLOW VOLUME = 6.53 HM3
FLOW DATE RANGE = 20010322 TO 20011030
SAMPLE DATE RANGE = 20010326 TO 20010907

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	72601.1	118912.8	.5935E+09	11109.85	.205
2 Q WTD C	71755.9	117528.5	.2467E+09	10980.52	.134
3 IJC	72875.9	119362.8	.2848E+09	11151.90	.141
4 REG-1	71854.6	117690.2	.2630E+09	10995.62	.138
5 REG-2	68680.4	112491.2	.2028E+09	10509.89	.127
6 REG-3	74660.7	122286.2	.3202E+09	11425.02	.146

APPENDIX D
BATHTUB FILES

APPENDIX D1
Uncalibrated Bathtub Model Files

CASE: Pheasant Lake Act/Cal 2001

HYDRAULIC AND DISPERSION PARAMETERS:

SEG	OUT	NET INFLOW HM3/YR	RESIDENCE TIME YRS	OVERFLOW RATE M/YR	MEAN VELOCITY KM/YR	----DISPERSION----- ESTIMATED KM2/YR	NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	7.15	.27604	7.6	16.0	1000.	35.	0.

CASE: Pheasant Lake Act/Cal 2001

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385083	96.639	2.210	.000E+00	.000	.023
2	1	385082	70.253	1.540	.000E+00	.000	.022
3	1	385081	59.570	3.080	.000E+00	.000	.052
4	1	385080	19.010	.729	.000E+00	.000	.038
5	4	380017	246.412	6.530	.000E+00	.000	.027
PRECIPITATION			.939	.921	.339E-01	.200	.980
TRIBUTARY INFLOW			245.473	7.559	.000E+00	.000	.031
***TOTAL INFLOW			246.412	8.480	.339E-01	.022	.034
GAUGED OUTFLOW			246.412	6.530	.000E+00	.000	.027
ADVECTIVE OUTFLOW			.000	.616	.194E+00	.715	-3095.554
***TOTAL OUTFLOW			246.412	7.146	.194E+00	.062	.029
***EVAPORATION			.000	1.334	.160E+00	.300	.000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385083	1290.4	33.2	.138E+05	28.2	.091	583.9	13.4
2	1	385082	792.7	20.4	.326E+04	6.7	.072	514.7	11.3
3	1	385081	1384.6	35.6	.285E+05	58.4	.122	449.5	23.2
4	1	385080	360.7	9.3	.248E+04	5.1	.138	494.8	19.0
5	4	380017	2886.3	74.3	.200E+05	41.0	.049	442.0	11.7
		PRECIPITATION	55.9	1.4	.780E+03	1.6	.500	60.7	59.5
		TRIBUTARY INFLOW	3828.3	98.6	.481E+05	98.4	.057	506.5	15.6
		***TOTAL INFLOW	3884.1	100.0	.488E+05	100.0	.057	458.1	15.8
		GAUGED OUTFLOW	3558.9	91.6	.127E+06	259.3	.100	545.0	14.4
		ADVECTIVE OUTFLOW	335.6	8.6	.588E+05	120.3	.722	545.0	********
		***TOTAL OUTFLOW	3894.4	100.3	.209E+06	428.6	.117	545.0	15.8
		***RETENTION	-10.3	-.3	.258E+06	528.6	9.999	.0	.0

HYDRAULIC OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL P POOL CONC MG/M3	TOTAL P RESIDENCE TIME YRS	TOTAL P TURNOVER RATIO -	TOTAL P RETENTION COEF -
7.61	.2760	545.0	.2768	1.8065	-.0026

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385083	3719.1	28.3	.470E+06	23.0	.184	1682.9	38.5
2	1	385082	2377.2	18.1	.224E+06	11.0	.199	1543.6	33.8
3	1	385081	4612.4	35.1	.965E+06	47.3	.213	1497.5	77.4
4	1	385080	1499.2	11.4	.166E+06	8.1	.272	2056.5	78.9
5	4	380017	12119.7	92.3	.511E+06	25.1	.059	1856.0	49.2
		PRECIPITATION	925.2	7.0	.214E+06	10.5	.500	1005.1	985.0
		TRIBUTARY INFLOW	12207.9	93.0	.183E+07	89.5	.111	1615.0	49.7
		***TOTAL INFLOW	13133.1	100.0	.204E+07	100.0	.109	1548.8	53.3
		GAUGED OUTFLOW	9586.0	73.0	.919E+06	45.1	.100	1468.0	38.9
		ADVECTIVE OUTFLOW	903.9	6.9	.426E+06	20.9	.722	1468.0	********
		***TOTAL OUTFLOW	10489.9	79.9	.152E+07	74.4	.117	1468.0	42.6
		***RETENTION	2643.2	20.1	.356E+07	174.4	.714	.0	.0

HYDRAULIC OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL N POOL CONC MG/M3	TOTAL N RESIDENCE TIME YRS	TOTAL N TURNOVER RATIO -	TOTAL N RETENTION COEF -
7.61	.2760	1468.0	.2205	2.2677	.2013

CASE: Pheasant Lake Act/Cal 2001

CASE: Pheasant Lake Act/Cal 2001

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 Deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STATISTICS 1	T STATISTICS 2	T STATISTICS 3
TOTAL P	MG/M3	545.0	.10	545.3	.46	1.00	.00	.00	.00
TOTAL N	MG/M3	1468.0	.10	1467.9	.16	1.00	.00	.00	.00
C.NUTRIENT	MG/M3	107.7	.10	107.7	.18	1.00	.00	.00	.00
CHL-A	MG/M3	19.3	.00	19.2	.33	1.00	.00	.01	.01
SECCHI	M	1.0	.00	1.0	.17	1.00	.00	-.02	-.03
ORGANIC N	MG/M3	1427.0	.00	1427.4	.18	1.00	.00	.00	.00
TP-ORTHO-P	MG/M3	487.0	.00	487.3	.16	1.00	.00	.00	.00

CASE: Pheasant Lake Act/Cal 2001

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE		VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P	MG/M3	545.00	545.27	99.7	99.7
TOTAL N	MG/M3	1468.00	1467.93	72.5	72.5
C.NUTRIENT	MG/M3	107.67	107.67	91.6	91.6
CHL-A	MG/M3	19.25	19.16	82.4	82.3
SECCHI	M	.96	.96	43.8	44.1
ORGANIC N	MG/M3	1427.00	1427.37	98.5	98.5
TP-ORTHO-P	MG/M3	487.00	487.35	99.8	99.8
ANTILOG PC-1		1089.24	1084.06	87.3	87.2
ANTILOG PC-2		9.28	9.28	75.7	75.7
(N - 150) / P		2.42	2.42	.2	.2
INORGANIC N / P		.71	.70	.0	.0
TURBIDITY	1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY		12.60	12.60	96.3	96.3
ZMIX / SECCHI		2.19	2.18	9.0	8.9
CHL-A * SECCHI		18.48	18.49	79.9	80.0
CHL-A / TOTAL P		.04	.04	.4	.3
FREQ(CHL-a>10) %		77.23	77.01	.0	.0
FREQ(CHL-a>20) %		35.50	35.23	.0	.0
FREQ(CHL-a>30) %		15.25	15.08	.0	.0
FREQ(CHL-a>40) %		6.81	6.72	.0	.0
FREQ(CHL-a>50) %		3.22	3.17	.0	.0
FREQ(CHL-a>60) %		1.60	1.57	.0	.0
CARLSON TSI-P		95.01	95.01	.0	.0
CARLSON TSI-CHLA		59.61	59.57	.0	.0
CARLSON TSI-SEC		60.59	60.52	.0	.0

Pheasant Lake Act/Cal 2001

SEGMENT NETWORK: FLOWS IN HM3/YR

*************** SEGMENT:	1 Deepest	INFLOW	OUTFLOW	EXCHANGE
PRECIP AND EVAPORATION:		.92	1.33	
EXTERNAL INFLOW:	1 385083	2.21		
EXTERNAL INFLOW:	2 385082	1.54		
EXTERNAL INFLOW:	3 385081	3.08		
EXTERNAL INFLOW:	4 385080	.73		
OUTFLOW / WITHDRAWAL:	5 380017		6.53	
DISCHARGE OUT OF SYSTEM:			.62	

APPENDIX D2
Calibrated Bathtub Model Files

CASE: Pheasant Lake Act/Cal 2001

HYDRAULIC AND DISPERSION PARAMETERS:

SEG	OUT	NET INFLOW HM3/YR	RESIDENCE TIME YRS	OVERFLOW RATE M/YR	MEAN VELOCITY KM/YR	----DISPERSION----- ESTIMATED KM2/YR	NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	7.15	.27604	7.6	16.0	1000.	35.	0.

CASE: Pheasant Lake Act/Cal 2001

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385083	96.639	2.210	.000E+00	.000	.023
2	1	385082	70.253	1.540	.000E+00	.000	.022
3	1	385081	59.570	3.080	.000E+00	.000	.052
4	1	385080	19.010	.729	.000E+00	.000	.038
5	4	380017	246.412	6.530	.000E+00	.000	.027
PRECIPITATION			.939	.921	.339E-01	.200	.980
TRIBUTARY INFLOW			245.473	7.559	.000E+00	.000	.031
***TOTAL INFLOW			246.412	8.480	.339E-01	.022	.034
GAUGED OUTFLOW			246.412	6.530	.000E+00	.000	.027
ADVECTIVE OUTFLOW			.000	.616	.194E+00	.715	-3095.554
***TOTAL OUTFLOW			246.412	7.146	.194E+00	.062	.029
***EVAPORATION			.000	1.334	.160E+00	.300	.000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	----- LOADING ---- KG/YR	%(I)	--- VARIANCE --- KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385083	1290.4	33.2	.138E+05	28.2	.091	583.9	13.4
2	1	385082	792.7	20.4	.326E+04	6.7	.072	514.7	11.3
3	1	385081	1384.6	35.6	.285E+05	58.4	.122	449.5	23.2
4	1	385080	360.7	9.3	.248E+04	5.1	.138	494.8	19.0
5	4	380017	2886.3	74.3	.200E+05	41.0	.049	442.0	11.7
PRECIPITATION			55.9	1.4	.780E+03	1.6	.500	60.7	59.5
TRIBUTARY INFLOW			3828.3	98.6	.481E+05	98.4	.057	506.5	15.6
***TOTAL INFLOW			3884.1	100.0	.488E+05	100.0	.057	458.1	15.8
GAUGED OUTFLOW			3558.9	91.6	.127E+06	259.3	.100	545.0	14.4
ADVECTIVE OUTFLOW			335.6	8.6	.588E+05	120.3	.722	545.0	********
***TOTAL OUTFLOW			3894.4	100.3	.209E+06	428.6	.117	545.0	15.8
***RETENTION			-10.3	-.3	.258E+06	528.6	9.999	.0	.0

HYDRAULIC		---------- TOTAL P			
OVERFLOW RATE	RESIDENCE TIME	POOL CONC	RESIDENCE TIME	TURNOVER RATIO	RETENTION COEF
M/YR	YRS	MG/M3	YRS	-	-
7.61	.2760	545.0	.2768	1.8065	-.0026

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385083	3719.1	28.3	.470E+06	23.0	.184	1682.9	38.5
2	1	385082	2377.2	18.1	.224E+06	11.0	.199	1543.6	33.8
3	1	385081	4612.4	35.1	.965E+06	47.3	.213	1497.5	77.4
4	1	385080	1499.2	11.4	.166E+06	8.1	.272	2056.5	78.9
5	4	380017	12119.7	92.3	.511E+06	25.1	.059	1856.0	49.2
PRECIPITATION			925.2	7.0	.214E+06	10.5	.500	1005.1	985.0
TRIBUTARY INFLOW			12207.9	93.0	.183E+07	89.5	.111	1615.0	49.7
***TOTAL INFLOW			13133.1	100.0	.204E+07	100.0	.109	1548.8	53.3
GAUGED OUTFLOW			9586.0	73.0	.919E+06	45.1	.100	1468.0	38.9
ADVECTIVE OUTFLOW			903.9	6.9	.426E+06	20.9	.722	1468.0	********
***TOTAL OUTFLOW			10489.9	79.9	.152E+07	74.4	.117	1468.0	42.6
***RETENTION			2643.2	20.1	.356E+07	174.4	.714	.0	.0

HYDRAULIC		---------- TOTAL N			
OVERFLOW RATE	RESIDENCE TIME	POOL CONC	RESIDENCE TIME	TURNOVER RATIO	RETENTION COEF
M/YR	YRS	MG/M3	YRS	-	-
7.61	.2760	1468.0	.2205	2.2677	.2013

CASE: Pheasant Lake Act/Cal 2001

CASE: Pheasant Lake Act/Cal 2001

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 Deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STATISTICS 1	T STATISTICS 2	T STATISTICS 3
TOTAL P	MG/M3	545.0	.10	545.3	.46	1.00	.00	.00	.00
TOTAL N	MG/M3	1468.0	.10	1467.9	.16	1.00	.00	.00	.00
C.NUTRIENT	MG/M3	107.7	.10	107.7	.18	1.00	.00	.00	.00
CHL-A	MG/M3	19.3	.00	19.2	.33	1.00	.00	.01	.01
SECCHI	M	1.0	.00	1.0	.17	1.00	.00	-.02	-.03
ORGANIC N	MG/M3	1427.0	.00	1427.4	.18	1.00	.00	.00	.00
TP-ORTHO-P	MG/M3	487.0	.00	487.3	.16	1.00	.00	.00	.00

CASE: Pheasant Lake Act/Cal 2001

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	545.00	545.27	99.7	99.7
TOTAL N MG/M3	1468.00	1467.93	72.5	72.5
C.NUTRIENT MG/M3	107.67	107.67	91.6	91.6
CHL-A MG/M3	19.25	19.16	82.4	82.3
SECCHI M	.96	.96	43.8	44.1
ORGANIC N MG/M3	1427.00	1427.37	98.5	98.5
TP-ORTHO-P MG/M3	487.00	487.35	99.8	99.8
ANTILOG PC-1	1089.24	1084.06	87.3	87.2
ANTILOG PC-2	9.28	9.28	75.7	75.7
(N - 150) / P	2.42	2.42	.2	.2
INORGANIC N / P	.71	.70	.0	.0
TURBIDITY 1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY	12.60	12.60	96.3	96.3
ZMIX / SECCHI	2.19	2.18	9.0	8.9
CHL-A * SECCHI	18.48	18.49	79.9	80.0
CHL-A / TOTAL P	.04	.04	.4	.3
FREQ(CHL-a>10) %	77.23	77.01	.0	.0
FREQ(CHL-a>20) %	35.50	35.23	.0	.0
FREQ(CHL-a>30) %	15.25	15.08	.0	.0
FREQ(CHL-a>40) %	6.81	6.72	.0	.0
FREQ(CHL-a>50) %	3.22	3.17	.0	.0
FREQ(CHL-a>60) %	1.60	1.57	.0	.0
CARLSON TSI-P	95.01	95.01	.0	.0
CARLSON TSI-CHLA	59.61	59.57	.0	.0
CARLSON TSI-SEC	60.59	60.52	.0	.0

Pheasant Lake Act/Cal 2001

SEGMENT NETWORK: FLOWS IN HM3/YR

*************** SEGMENT:	1 Deepest	INFLOW	OUTFLOW	EXCHANGE
PRECIP AND EVAPORATION:		.92	1.33	
EXTERNAL INFLOW:	1 385083	2.21		
EXTERNAL INFLOW:	2 385082	1.54		
EXTERNAL INFLOW:	3 385081	3.08		
EXTERNAL INFLOW:	4 385080	.73		
OUTFLOW / WITHDRAWAL:	5 380017		6.53	
DISCHARGE OUT OF SYSTEM:			.62	

APPENDIX D3
Calibrated Bathtub Model with 50%Reduction in External Load

CASE: Pheasant Lake 50% External

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	545.00	276.08	99.7	97.4
TOTAL N MG/M3	1468.00	786.23	72.5	35.2
C.NUTRIENT MG/M3	107.67	52.07	91.6	68.1
CHL-A MG/M3	19.25	17.18	82.4	78.4
SECCHI M	.96	1.71	43.8	72.8
ORGANIC N MG/M3	1427.00	1365.84	98.5	98.1
TP-ORTHO-P MG/M3	487.00	477.39	99.8	99.8
ANTILOG PC-1	1089.24	501.07	87.3	70.8
ANTILOG PC-2	9.28	14.62	75.7	94.1
(N - 150) / P	2.42	2.30	.2	.2
INORGANIC N / P	.71	1.00	.0	.0
TURBIDITY 1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY	12.60	12.60	96.3	96.3
ZMIX / SECCHI	2.19	1.23	9.0	1.0
CHL-A * SECCHI	18.48	29.43	79.9	93.3
CHL-A / TOTAL P	.04	.06	.4	3.6
FREQ(CHL-a>10) %	77.23	71.34	.0	.0
FREQ(CHL-a>20) %	35.50	28.95	.0	.0
FREQ(CHL-a>30) %	15.25	11.34	.0	.0
FREQ(CHL-a>40) %	6.81	4.72	.0	.0
FREQ(CHL-a>50) %	3.22	2.11	.0	.0
FREQ(CHL-a>60) %	1.60	1.00	.0	.0
CARLSON TSI-P	95.01	85.20	.0	.0
CARLSON TSI-CHLA	59.61	58.50	.0	.0
CARLSON TSI-SEC	60.59	52.25	.0	.0

APPENDIX D4
Calibrated Bathtub Model with 75% Reduction in External Load

CASE: Pheasant Lake 25% External

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE		VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P	MG/M3	545.00	142.09	99.7	88.7
TOTAL N	MG/M3	1468.00	453.82	72.5	10.8
C.NUTRIENT	MG/M3	107.67	24.93	91.6	32.7
CHL-A	MG/M3	19.25	13.72	82.4	68.9
SECCHI	M	.96	3.06	43.8	91.5
ORGANIC N	MG/M3	1427.00	1258.00	98.5	97.2
TP-ORTHO-P	MG/M3	487.00	459.93	99.8	99.8
ANTILOG PC-1		1089.24	212.12	87.3	45.6
ANTILOG PC-2		9.28	21.29	75.7	98.9
(N - 150) / P		2.42	2.14	.2	.1
INORGANIC N / P		.71	1.00	.0	.0
TURBIDITY	1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY		12.60	12.60	96.3	96.3
ZMIX / SECCHI		2.19	.69	9.0	.0
CHL-A * SECCHI		18.48	42.05	79.9	97.7
CHL-A / TOTAL P		.04	.10	.4	13.3
FREQ(CHL-a>10) %		77.23	57.94	.0	.0
FREQ(CHL-a>20) %		35.50	17.93	.0	.0
FREQ(CHL-a>30) %		15.25	5.80	.0	.0
FREQ(CHL-a>40) %		6.81	2.09	.0	.0
FREQ(CHL-a>50) %		3.22	.83	.0	.0
FREQ(CHL-a>60) %		1.60	.36	.0	.0
CARLSON TSI-P		95.01	75.62	.0	.0
CARLSON TSI-CHLA		59.61	56.29	.0	.0
CARLSON TSI-SEC		60.59	43.86	.0	.0

APPENDIX D5
Calibrated Bathtub Model with 90% Reduction in External Load

CASE: Pheasant Lake 10% External

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	545.00	64.28	99.7	62.8
TOTAL N MG/M3	1468.00	248.98	72.5	1.5
C.NUTRIENT MG/M3	107.67	8.18	91.6	3.3
CHL-A MG/M3	19.25	8.25	82.4	43.3
SECCHI M	.96	7.39	43.8	99.4
ORGANIC N MG/M3	1427.00	1087.77	98.5	94.8
TP-ORTHO-P MG/M3	487.00	432.38	99.8	99.8
ANTILOG PC-1	1089.24	52.28	87.3	11.9
ANTILOG PC-2	9.28	33.37	75.7	99.9
(N - 150) / P	2.42	1.54	.2	.0
INORGANIC N / P	.71	1.00	.0	.0
TURBIDITY 1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY	12.60	12.60	96.3	96.3
ZMIX / SECCHI	2.19	.28	9.0	.0
CHL-A * SECCHI	18.48	60.96	79.9	99.4
CHL-A / TOTAL P	.04	.13	.4	25.3
FREQ(CHL-a>10) %	77.23	26.75	.0	.0
FREQ(CHL-a>20) %	35.50	4.11	.0	.0
FREQ(CHL-a>30) %	15.25	.84	.0	.0
FREQ(CHL-a>40) %	6.81	.21	.0	.0
FREQ(CHL-a>50) %	3.22	.07	.0	.0
FREQ(CHL-a>60) %	1.60	.02	.0	.0
CARLSON TSI-P	95.01	64.18	.0	.0
CARLSON TSI-CHLA	59.61	51.30	.0	.0
CARLSON TSI-SEC	60.59	31.18	.0	.0

APPENDIX D6
Calibrated Bathtub Model with 50% Reduction in External Load and 25% Reduction in Internal Load

CASE: Pheasant 50% Ext/75% Internal

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

	----- VALUES -----		--- RANKS (%) ----	
VARIABLE	OBSERVED	ESTIMATED	OBSERVED	ESTIMATED
TOTAL P MG/M3	545.00	267.88	99.7	97.2
TOTAL N MG/M3	1468.00	658.01	72.5	25.6
C.NUTRIENT MG/M3	107.67	41.81	91.6	57.8
CHL-A MG/M3	19.25	17.06	82.4	78.1
SECCHI M	.96	2.04	43.8	79.8
ORGANIC N MG/M3	1427.00	1271.23	98.5	97.3
TP-ORTHO-P MG/M3	487.00	341.83	99.8	99.5
ANTILOG PC-1	1089.24	394.27	87.3	64.2
ANTILOG PC-2	9.28	16.91	75.7	96.7
(N - 150) / P	2.42	1.90	.2	.1
INORGANIC N / P	.71	1.00	.0	.0
TURBIDITY 1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY	12.60	12.60	96.3	96.3
ZMIX / SECCHI	2.19	1.03	9.0	.4
CHL-A * SECCHI	18.48	34.75	79.9	95.8
CHL-A / TOTAL P	.04	.06	.4	3.9
FREQ(CHL-a>10) %	77.23	70.95	.0	.0
FREQ(CHL-a>20) %	35.50	28.56	.0	.0
FREQ(CHL-a>30) %	15.25	11.12	.0	.0
FREQ(CHL-a>40) %	6.81	4.61	.0	.0
FREQ(CHL-a>50) %	3.22	2.05	.0	.0
FREQ(CHL-a>60) %	1.60	.97	.0	.0
CARLSON TSI-P	95.01	84.77	.0	.0
CARLSON TSI-CHLA	59.61	58.43	.0	.0
CARLSON TSI-SEC	60.59	49.75	.0	.0

APPENDIX D7
Calibrated Bathtub Model with 50% Reduction in External Load and 50%Reduction in Internal Load

CASE: Pheasant 50% Ext/50% Internal

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE	----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P MG/M3	545.00	259.66	99.7	97.0
TOTAL N MG/M3	1468.00	654.84	72.5	25.3
C.NUTRIENT MG/M3	107.67	41.53	91.6	57.5
CHL-A MG/M3	19.25	16.93	82.4	77.8
SECCHI M	.96	2.05	43.8	80.0
ORGANIC N MG/M3	1427.00	1176.92	98.5	96.3
TP-ORTHO-P MG/M3	487.00	322.18	99.8	99.4
ANTILOG PC-1	1089.24	379.39	87.3	63.1
ANTILOG PC-2	9.28	16.70	75.7	96.5
(N - 150) / P	2.42	1.94	.2	.1
INORGANIC N / P	.71	1.00	.0	.0
TURBIDITY 1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY	12.60	12.60	96.3	96.3
ZMIX / SECCHI	2.19	1.03	9.0	.4
CHL-A * SECCHI	18.48	34.67	79.9	95.8
CHL-A / TOTAL P	.04	.07	.4	4.2
FREQ(CHL-a>10) %	77.23	70.52	.0	.0
FREQ(CHL-a>20) %	35.50	28.14	.0	.0
FREQ(CHL-a>30) %	15.25	10.88	.0	.0
FREQ(CHL-a>40) %	6.81	4.49	.0	.0
FREQ(CHL-a>50) %	3.22	1.99	.0	.0
FREQ(CHL-a>60) %	1.60	.94	.0	.0
CARLSON TSI-P	95.01	84.32	.0	.0
CARLSON TSI-CHLA	59.61	58.35	.0	.0
CARLSON TSI-SEC	60.59	49.67	.0	.0

APPENDIX D8
Calibrated Bathtub Model with 50% Reduction in External Load and 75% Reduction in Internal Load

CASE: Pheasant 50% Ext/25% Internal

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE		----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P	MG/M3	545.00	251.51	99.7	96.7
TOTAL N	MG/M3	1468.00	651.86	72.5	25.1
C.NUTRIENT	MG/M3	107.67	41.25	91.6	57.2
CHL-A	MG/M3	19.25	16.80	82.4	77.5
SECCHI	M	.96	2.06	43.8	80.2
ORGANIC N	MG/M3	1427.00	1081.99	98.5	94.7
TP-ORTHO-P	MG/M3	487.00	244.94	99.8	98.6
ANTILOG PC-1		1089.24	364.14	87.3	61.9
ANTILOG PC-2		9.28	16.46	75.7	96.3
(N - 150) / P		2.42	2.00	.2	.1
INORGANIC N / P		.71	.15	.0	.0
TURBIDITY	1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY		12.60	12.60	96.3	96.3
ZMIX / SECCHI		2.19	1.02	9.0	.4
CHL-A * SECCHI		18.48	34.57	79.9	95.8
CHL-A / TOTAL P		.04	.07	.4	4.5
FREQ(CHL-a>10) %		77.23	70.07	.0	.0
FREQ(CHL-a>20) %		35.50	27.70	.0	.0
FREQ(CHL-a>30) %		15.25	10.64	.0	.0
FREQ(CHL-a>40) %		6.81	4.37	.0	.0
FREQ(CHL-a>50) %		3.22	1.93	.0	.0
FREQ(CHL-a>60) %		1.60	.91	.0	.0
CARLSON TSI-P		95.01	83.86	.0	.0
CARLSON TSI-CHLA		59.61	58.28	.0	.0
CARLSON TSI-SEC		60.59	49.60	.0	.0

APPENDIX D9
Calibrated Bathtub Model with 50% Reduction in External Load and 90% Reduction in Internal Load

CASE: Pheasant 50% Ext/10% Internal

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Deepest

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	545.00	246.53	99.7	96.6
TOTAL N MG/M3	1468.00	649.60	72.5	24.9
C.NUTRIENT MG/M3	107.67	41.05	91.6	56.9
CHL-A MG/M3	19.25	16.71	82.4	77.3
SECCHI M	.96	2.07	43.8	80.3
ORGANIC N MG/M3	1427.00	1026.36	98.5	93.5
TP-ORTHO-P MG/M3	487.00	214.84	99.8	98.1
ANTILOG PC-1	1089.24	354.59	87.3	61.1
ANTILOG PC-2	9.28	16.32	75.7	96.2
(N - 150) / P	2.42	2.03	.2	.1
INORGANIC N / P	.71	.03	.0	.0
TURBIDITY 1/M	6.00	6.00	99.5	99.5
ZMIX * TURBIDITY	12.60	12.60	96.3	96.3
ZMIX / SECCHI	2.19	1.02	9.0	.4
CHL-A * SECCHI	18.48	34.52	79.9	95.7
CHL-A / TOTAL P	.04	.07	.4	4.7
FREQ(CHL-a>10) %	77.23	69.78	.0	.0
FREQ(CHL-a>20) %	35.50	27.42	.0	.0
FREQ(CHL-a>30) %	15.25	10.49	.0	.0
FREQ(CHL-a>40) %	6.81	4.29	.0	.0
FREQ(CHL-a>50) %	3.22	1.89	.0	.0
FREQ(CHL-a>60) %	1.60	.89	.0	.0
CARLSON TSI-P	95.01	83.57	.0	.0
CARLSON TSI-CHLA	59.61	58.22	.0	.0
CARLSON TSI-SEC	60.59	49.54	.0	.0

Appendix B
Formal Comments

EPA REGION VIII TMDL REVIEW FORM

Document Name:	**Pheasant Lake Nutrient and Dissolved Oxygen TMDLs**
Submitted by:	**Mike Ell, NDDoH**
Date Received:	**September 13, 2006**
Review Date:	**October 4, 2006**
Reviewer:	**Vern Berry, EPA**
Formal or Informal Review?	**Informal - Public Notice**

This document provides a standard format for EPA Region 8 to provide comments to the North Dakota Department of Health (NDDoH) on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy
12. Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. **Water Quality Impairment Status**

Criterion Description – Water Quality Impairment Status

TMDL documents must include a description of the listed water quality impairments. *While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired*

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☒ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Pheasant Lake is located near the town of Ellendale in Dickey County, North Dakota. It is a 165.8 acre man-made impoundment on the Elm River in the James River basin of North Dakota. The Elm River and three small, unnamed tributaries drain into the lake. The Lake is listed on the State's 2004 303(d) list as impaired for aquatic life and recreational uses by nutrients/eutrophication, and for aquatic life for low dissolved oxygen and sediment. Approximately 60,940 acres of land drain to the lake from the watershed. Pheasant Lake is classified as a Class 3 warm water fishery, and is listed as a high priority (i.e., 1A) for TMDL development. The majority of the land use in this watershed is agricultural (approximately 88 percent). Cropland acreage is approximately 42%, pastureland is approximately 37% and alfalfa/hay is approximately 9%.

COMMENTS - The Pheasant Lake 303(d) listing for sediment is not clearly addressed in this document. A previous draft indicated that sediment will be addressed at a later time when a better sediment target is established. This document is silent in that respect. However, the document still mentions inclusion of a sediment TMDL in several places (e.g., on the document title inside the front cover, in the list of tables, in the first sentence of Section 7.0). Similar to other lake/reservoir TMDLs developed by NDDoH recently, it seems possible that enough sediment data exists for Pheasant Lake to conclude that it is not impaired by sediment. If such data exists to make this conclusion, then adequate justification needs to be added to the document as to why a sediment TMDL is not needed (See Dead Colt Creek Dam TMDL, Northgate Dam TMDL, or Carbury Dam TMDL), and the document needs to say that the sediment impairment will be removed from the State's list during the next 303(d) listing cycle. Alternatively, the document needs to say that the sediment impairment will be addressed in a future TMDL for Pheasant Lake.

2. **Water Quality Standards**

Criterion Description – Water Quality Standards

The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including

☒ Satisfies Criterion
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☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Pheasant Lake is impaired for dissolved oxygen and nutrients/eutrophication and sedimentation/siltation. The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters of the state. The NDDoH narrative standards that apply to nutrients and sedimentation include:

> *"All waters of the state shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to humans, animals, plants, or resident aquatic biota."* (See NDAC 33-16-02-08.1.a.(4))
>
> *"No discharge of pollutants, which alone or in combination with other substances, shall:*
> *1. Cause a public health hazard or injury to environmental resources;*
> *2. Impair existing or reasonable beneficial uses of the receiving waters; or*
> *3. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters." (See NDAC 33-16-02-08.1.e.)*

In addition to the narrative standards, the NDDH has set a biological goal for all surface waters of the state:

> *"The biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites." (See NDAC 33-16-02-08.2.a.)*

Currently, North Dakota does not have a numeric standard for nutrients, however nutrient guidelines for lakes have been established. The nutrient guidelines for lakes are: NO_3 as N = 0.25 mg/L; PO_4 as P = 0.02 mg/L; and total phosphorous = 0.1 mg/L.

The numeric standard for dissolved oxygen is $\geq$ 5.0 mg/L (single sample minimum).

Other applicable water quality standards are included on pages 18 - 19 of the TMDL report.

3. Water Quality Targets

Criterion Description – Water Quality Targets

Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the TMDL target. For pollutants with narrative standards, the narrative standard must be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
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☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The main water quality target for this TMDL is based on interpretation of narrative provisions found in State water quality standards. In North Dakota, algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. Several algal species are considered to be nuisance aquatic species. TSI measurements can be used to estimate how much algal production may occur in lakes. Therefore, TSI is used as a measure of the narrative standard in order to determine whether beneficial uses are being met.

Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that a 50% reduction in external phosphorous loading to the lake will achieve a chlorophyll-a TSI of 58.50 and a Secchi disk TSI of 52.25, which corresponds to a phosphorous concentration of 0.365 mg/L. This target is based on best professional judgement and will fully support its beneficial uses.

The water quality targets used in this TMDL are: **maintain a mean annual chlorphyll-a TSI at or below 58.50 and Secchi disk TSI at or below 52.25; maintain a dissolved oxygen level of not less than 5 mg/L.**

4. Significant Sources

Criterion Description – Significant Sources

TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach can be employed so long as the approach is clearly defined in the

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SUMMARY – The TMDL identifies the major sources of phosphorous as coming from nonpoint source agricultural landuses within the watershed. In particular, a loading analysis was done for nutrients and sediment considering various agricultural land use and land management factors. Cropland and pastureland are the primary sources identified. Approximately 42% of the landuse is cropland, 37% is pastureland and 9% is alfalfa/hay in the watershed.

5. Technical Analysis

Criterion Description – Technical Analysis

TMDLs must be supported by an appropriate level of technical analysis. It applies to ***all*** *of the components of a TMDL document. It is vitally important that the technical basis for* ***all*** *conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.

☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The technical analysis addresses the needed phosphorous reduction to achieve the desired water quality. The TMDL recommends a 50% reduction in external average annual total phosphorous loads to Pheasant Lake. Based on the loads measured during the period of the assessment the total phosphorous load should be 1,940.0 kg/yr to achieve the proposed TP TSI target. This reduction is based in large part on the BATHTUB mathematical modeling of the Lake and its predicted response to nutrient load reductions. The FLUX model was used to facilitate the analysis and reduction of tributary inflow and outflow nutrient and sediment loadings for the Pheasant Lake. Output from the FLUX program is then provided as an input file to calibrate the BATHTUB eutrophication response model.

The Agricultural Non-Point Source Model (AGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The nutrient loading source analysis, that was used to identify necessary controls in the watershed, was based on the identification of critical cells and highly critical cells (i.e., those with phosphorous loading rates above 1.5 lbs/acre and 3.0 lbs/acre respectively). The initial load reductions specified by this TMDL will be achieved through controls on the critical cells within the watershed to improve pasture conditions or improve tillage practices.

Improvements in the dissolved oxygen concentration of the lake can be achieved through reduction of organic loading to the lake as a result of proposed BMP implementation. The TMDL contains a linkage analysis between phosphorous loading and low dissolved oxygen in lakes and reservoirs. It is anticipated that meeting the phosphorous load reduction target in Pheasant Lake will address the dissolved oxygen impairment.

6. Margin of Safety and Seasonality

Criterion Description – Margin of Safety and Seasonality

A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.

Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered

☒ Satisfies Criterion
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☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – A 10% explicit margin of safety is specified in the nutrient TMDL of 194 kg/yr of phosphorous. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing BMPs that can be tailored to seasonal needs.

7. TMDL

Criterion Description – Total Maximum Daily Load

TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL established for Pheasant Lake is a 1940.0 kg/yr total phosphorus load to the lake (50% reduction in external annual total phosphorus load). This is the "measured load" which derived from the BATHTUB model using the flow and concentration data collected during the period of the assessment. The annual loading will vary from year-to-year; therefore, this TMDL is considered a long term average percent reduction in phosphorous loading. The TMDL contains a linkage analysis between phosphorous loading and low dissolved oxygen in lakes and reservoirs. It is anticipated that meeting the phosphorous load reduction target in Pheasant Lake will address the dissolved oxygen impairment.

8. Allocation

Criterion Description – Allocation

TMDLs apportion responsibility for taking actions or allocate the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources. Every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Pheasant Lake. The allocations in the TMDL include a "load allocation" attributed agricultural to nonpoint sources, and an explicit margin of safety. The source allocations for phosphorous are assigned to the critical loading cells that contribute greater than 1.5 tons/acre of phosphorous. The percentage of the subwatershed areas with critical phosphorous loading is shown in Figure 29 of the TMDL. There is a desire to move forward with controls in the areas of the basin where there is confidence that phosphorous reductions can be achieved through modifications to critical cells within the watershed.

9. Public Participation

Criterion Description – Public Participation

The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for review, a copy of the comments received by the state should be also submitted to EPA.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL includes a summary of the public participation process that has occurred. It describes the opportunities the public had to be involved in the TMDL development process. Copies of the draft TMDL were mailed to stakeholders in the watershed during public comment. Also, the draft TMDL was be posted on NDoDH's Water Quality Division website, and a public notice for comment was published in three newspapers.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy

TMDLs may have significant uncertainty associated with selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Future monitoring is recommended in Section 10.0 of the TMDL to address margin of safety and seasonality needs, as well as provide additional data to ensure that the goals of the TMDL are met.

11. Restoration Strategy

Criterion Description – Restoration Strategy

At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. Adding additional detail regarding the proposed approach for the restoration of water quality <u>*is not*</u> *currently a regulatory requirement, but is considered a value added component of a TMDL document.*

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The North Dakota Department of Health will work with the local soil conservation district, local volunteer groups and landowners to initiate restoration projects in the watershed.

12. Endangered Species Act Compliance

Criterion Description – Endangered Species Act Compliance

EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act (ESA). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with USFWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – EPA will request ESA Section 7 concurrence from the USFWS for this TMDL.

Appendix C
Letters of Support

Don Meidinger

From: "Don Meidinger" <dmdinger@drtel.net>
To: "dmdinger" <dmdinger@drtel.net>
Sent: Friday, October 06, 2006 12:09 PM
Subject: Fw: TMDL

Please E-mail Receiving

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 1
To MR. Michael Ell	From Don Meidinger
Co. Department of Health	Co.
Dept. Water Quality	Phone # 701 349-3358
Fax # 701 328 5200	Fax # 701 349-3903

Pheasant Lake Neighborhood Association
P.O. Box 70
Ellendale, North Dakota 58436-0070
October 4, 2006

North Dakota Department of Health
Division of Water Quality
Mr. Michael J. Ell
Environmental Admistrator
Gold Seal Center, 918 E. Divide Ave.
Bismarck, ND 58501-1947

Mr. Ell

The Pheasant Lake Homeowners Association wishes to respond and comment on the recently published notification, concerning the finding of the "Pheasant Lake Total Maximum Daily Load" (TMDL) report.

As an Association we are supportive of the draft results, and wish to be involved with implementing and instituting measures deemed necessary to improve the water quality of Pheasant Lake, by lowering and minimizing the amount of nutrients and sediment loading from the watersheds entering Pheasant Lake.

We are of the consensus, the study to be worthy and beneficial endeavor for the betterment and longevity of Pheasant Lake, as well as long term benefits to the surrounding watershed.

Your continued efforts to this end are greatly appreciated. As an Association we have met with the Dickey County Commissioners and expressed our desire for there support for continued efforts for the improvement of the water quality of Pheasant Lake.

Pheasant Lake Neighborhood Association
Board of Directors Meeting
October 3, 2006

Attested By:
Donald D Meidinger
President: Donald D Meidinger

Livy Hird
Secretary/Treasurer: Livy Hird

10/10/2006

DICKEY COUNTY WATER RESOURCE BOARD

Board Members: *Secretary: Hope Jury – Phone 375-6311*
Don K. Zimbleman,Chairman – Fullerton – Phone 375-6721
Keith Hauck, Vice chairman – Forbes – Phone 357-7351
Larry Hoffman – Ellendale –Phone 349-3249 ext 3
Kevin Strobel – Kulm – Phone 647-2054
Norm Haak – Oakes – Phone 742-2023

November 20, 2006

North Dakota Department of Health
Division of Water Quality
Mr. Michael Ell, Environmental Administrator
Gold Seal Center, 918 E. Divide Ave.
Bismarck, North Dakota 58501-1947

Dear Mr. Ell,

The Dickey County Water Resource Board reviewed the report entitled, "Nutrient and Dissolved Oxygen TMDLs for Pheasant Lake in Dickey County, North Dakota" and would like to comment on the findings.

We welcome your suggestions for reducing the amount of nutrients and sediments from the watershed areas entering Pheasant Lake and hope to be part of the solution to implement the suggestions. As such, we hope that you will continue to work toward and keep us informed about any further efforts to improve the quality of Pheasant Lake.

We appreciate the work put into the report and hope that it will serve as a catalyst to turn Pheasant Lake once more into a viable fishery and recreational lake.

Hope A. Jury

Hope A. Jury, Secretary, DCWRB

Appendix D
Department Response To All Comments

During the 30 day public notice soliciting comment and participation for the Pheasant Lake Nutrient and Dissolved Oxygen TMDLs held from September 1 to October 11, 2006. The North Dakota Department of Health received a formal letter from Vern Berry of the Environmental Protection Agency (EPA) dated October 4, 2006. Below are the comments made and the section(s) they address and the departments' response. A letter of support was also received during the 30 day public notice period from Don Meidinger President of the Pheasant Lake Neighborhood Association dated October 4, 2006.

Environmental Protection Agency (EPA) Comments

Section 1.5.6 Tributary Total Suspended Solids

Comment from EPA: "The Pheasant Lake 303(d) listing for sediment is not clearly addressed in this document. A previous draft indicated that sediment will be addressed at a later time when a better sediment target is established. This document is silent in that respect. However, the document still mentions inclusion of a sediment TMDL in several places (e.g., on the document title inside the front cover, in the list of tables, in the first sentence of Section 7.0). Similar to other lake/reservoir TMDLs developed by NDDoH recently, it seems possible that enough sediment data exists for Pheasant Lake to conclude that it is not impaired by sediment. If such data exists to make this conclusion, then adequate justification needs to be added to the document as to why a sediment TMDL is not needed (See Dead Colt Creek Dam TMDL, Northgate Dam TMDL, or Carbury Dam TMDL), and the document needs to say that the sediment impairment will be removed from the State's list during the next 303(d) listing cycle. Alternatively, the document needs to say that the sediment impairment will be addressed in a future TMDL for Pheasant Lake."

NDDOH Response: Corrections have been made to the document pertaining to the sediment impairment per EPA request. Language was added to Section 1.5.6 concerning Pheasant Lake's 303(d) listing for sediment impairment which will be addressed in a future TMDL once sufficient research has been conducted in North Dakota establishing a sediment target for the state.